October 1993/$3.00

Mobile Radio Technology

The journal of mobile communications technology

RF radiation guidelines, p. 10

2,400-baud paging
Analog vs. digital cellular
Radiating coaxial cable
F-TDMA
Receiver desensitization

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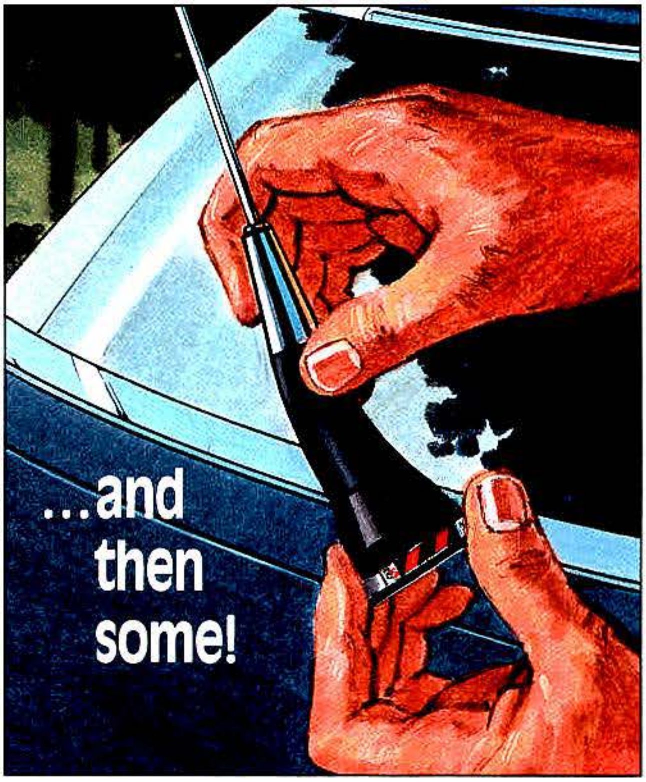

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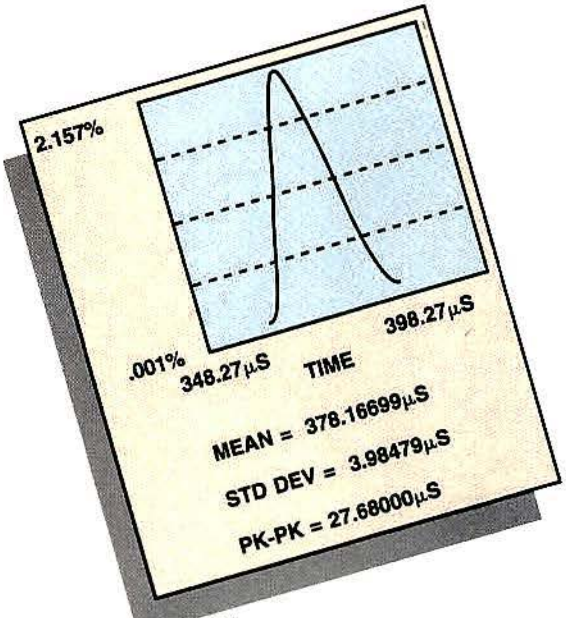
Contents

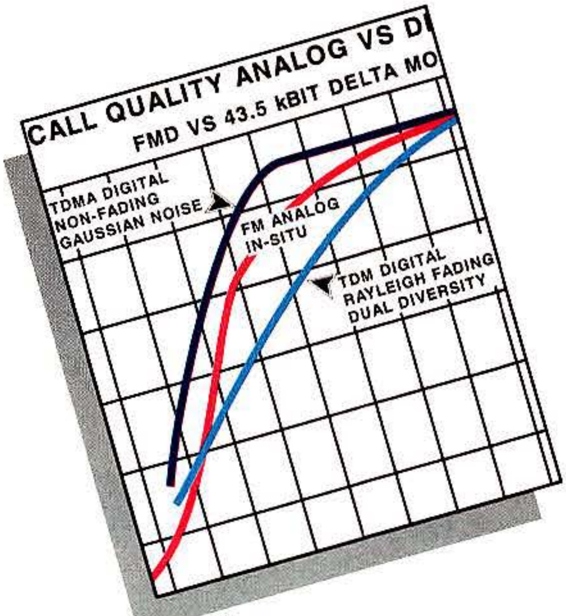
Mobile Radio Technology

Volume 11, Issue 10

The journal of mobile communications technology



page 14



page 24

features

departments

On the cover: A worker wears a radio frequency radiation (RFR) protective suit of Naptex fabric made with yarn consisting of stainless-steel microfibers in a cotton-polyester base while making RFR measurements near antennas on a tower. Photo courtesy of Maxwell Safety Products, Smithtown, NY.

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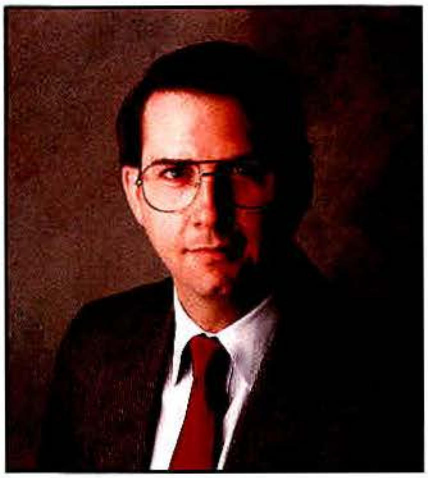
Editorial

Wanted: The General Radiotelephone Operator License



It's a funny business, this matter of radio communications technician licensing and certification.

Several years ago, the FCC deregulated land mobile radio maintenance and repair by eliminating the previous requirement that such work be performed by technicians with a General Radiotelephone Operator License (GROL).

Some employers without the means or desire to test job applicants continued to list the GROL as a technician employment requirement. Others made use of private technician testing and certification.

To save money and to discourage people from applying for the GROL, the FCC reduced its testing schedule. The GROL test not only became outdated, it became hard to get.

To fill the void, several trade associations began giving tests and issuing certificates to successful candidates; nevertheless, some technicians and employers continued to prefer the government's GROL to association certificates.

One association went so far as to petition the government—unsuccessfully—to stop issuing GROLs.

The FCC tells license candidates by phone and by mail that the license is not required for land mobile technicians.

On Sept. 1, the government took two steps that respond to public demand for the license. It released an updated pool of exam questions and made the test available through multiple private outlets.

The exam measures an applicant's knowledge of basic radio law and operating practice for *maritime* radio. It asks questions about electronic fundamentals and techniques required to adjust, repair and maintain radio transmitters and receivers in the *aviation, maritime* and *international fixed public* radio services, not land mobile radio.

As far as land mobile radio is concerned, now the GROL test is readily available to people who still do not *need* the license as an FCC requirement, but who nevertheless *want* it or whose *employers* want them to have it.

Examinations are available through nine private companies and trade associations selected by the FCC from 60 applicants to serve as commercial operator license examination managers (COLEMs).

To obtain a GROL, applicants send a proof-of-passing certificate from a COLEM and an FCC Form 756 to the FCC at 1270 Fairfield Road, Gettysburg, PA 17325-7245.

Some of the COLEMs are offering study guides, classes and copies of the question pools. Information can be obtained directly from these organizations, which are listed below.

A representative of one of the COLEMs said that because the new questions are difficult, she expects a high failure rate among the first round of candidates taking test elements for the GROL.

Her company, which offers a variety of industrial and government tests, has tentative plans to offer five-day classes at teleconferencing locations throughout the country to prepare test candidates. Such classes are especially popular among people preparing to take a test for a *second* time, she said.

All this for a license that is "not required" for land mobile radio, but that some technicians and employers still want.

—Don Bishop

Commercial operator license examination managers

Drake Training and Technologies
8800 Queen Ave. South
Bloomington, MN 55431
800-401-EXAM
FAX 612-921-7248
Contact: Julie Johnson
Fee: $60 per exam
Testing: Daily by appointment, 200 locations in North America, 300 locations overseas.

Electronic Technicians Association International
602 N. Jackson St.
Greencastle, IN 46135
317-653-4301
FAX 317-653-8262
Contact: Anne Boiles
Fee: $35-$75
Testing: In every state, plus some stateside and overseas military facilities. Call for schedule.

Elkins Institute Inc.
P.O. Box 797666
Dallas, TX 75379
800-944-1603
FAX 214-732-0244
Contact: Ed Lyda
Fee: $50 for first element, $25 for each additional element taken at the same sitting.
Testing: In every state, scheduled and by appointment.

International Society of Certified Electronics Technicians
2708 W. Berry St.
Fort Worth, TX 76109
Contact: Dept. 19
817-921-9101
FAX 817-921-3741
Fee: $25-$75 per element
Testing: In every state except Alaska, Vermont and Wyoming, and in Guam and selected foreign countries, by appointment.

National Association of Business and Educational Radio
1501 Duke St.
Alexandria, VA 22314
800-759-0300
FAX 703-836-1608
Contact: FCC Technician Testing Center
Fee: $63-$120
Testing: At 95 test centers five days a week.

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FAX 410-880-8714
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National Association of Radio Telecommunications Engineers
P.O. Box 678
Medway, MA 02053
11 Awl St.
Medway, MA 02053
508-533-8333
FAX 508-533-3815
Contact: Susan Stillwell
Fee: $40 per exam per sitting.

W5YI Group
National Radio Examiners Division
P.O. Box 565206
Dallas, TX 75356-5206
2000 E. Randol Mill Road
Suite 608-A
Arlington, TX 76011
817-461-6443
FAX 817-548-9594
Contact: Frederick O. Maia
Fee: $35 per license
Testing: In all states and other locations, monthly or quarterly depending upon demand.

Calendar

October

18-19—SMR Management Conference, sponsored by American Mobile Telecommunications Association, Hyatt Regency Tech Center, Denver. Contact: 202-331-7773.

21-23—Government Affairs Summit/Fall Meeting, sponsored by the National Association of Business and Educational Radio (NABER), Ritz-Carlton Hotel, McLean, VA. Contact: 800-759-0300.

November

2-4—WirelessWorld Conference & Exhibition, sponsored by *Cellular Business* magazine, Buena Vista Palace, Lake Buena Vista, FL. Contact: Chris Lotesto, 800-458-0479.

4-6—Industrial Telecommunications Association, La Quinta Hotel, La Quinta, CA. Contact: Barbara J. Levermann, 703-528-5115.

11-14—Communications Marketing Conference, Holiday Inn Riverwalk, San Antonio. Contact: Gene Johnson, Vega Signaling, 818-442-0782.

19—Radio Club of America, Communications Symposium, Annual Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Ron Formella, 201-652-6811.

1994

February

7-8—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, Marriott on International Drive, Orlando, FL. Contact: 202-331-7773.

March

2-4—Cellular Telecommunications Industry Association Winter Meeting and Exposition, San Diego. Contact: 202-785-0081.

6-9—Energy Telecommunications and Electrical Association, Henry B. Gonzales Convention Center, San Antonio. Contact: 214-235-0655.

April

13-15—International Wireless Communications Expo/Spring, Las Vegas Convention Center, Las Vegas. Contact: 303-220-0600.

May

2-5—Supercomm, sponsored by USTA and TIA, and **International Conference on Communications,** sponsored by IEEE, New Orleans. Contact: USTA, 202-835-3100.

12-14—Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Peabody Hotel, Orlando, FL. Contact: Nancy Palleschi, 800-759-0300.

25-27—RadioComm, Vancouver Convention Center, Vancouver, British Columbia. Contact: Bill Eggertson, 613-233-4888.

June

7-11—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Stockholm, Sweden. Contact: Professor Sven-Olof Ohrvik, technical chairman, 46 8 757 0483; Fax 46 8 34 8441.

18-23—Utilities Telecommunications Council, Washington Sheraton, Washington, DC. Contact: Rita Clark, 301-621-7802.

July

17-20—Forestry-Conservation Communications Association, Hershey, PA. Contact: Don Pfohl, 602-644-3166.

August

6-11—International Municipal Signal Association, Cavenaugh's Inn, Spokane, WA. Contact: Harold Glerum, 800-723-4672.

7-12—Associated Public-Safety Communications Officers National Conference, Lawrence Convention Center, Pittsburgh. Contact: 800-824-1850.

September

22-24—Mobile Communications Marketplace, Washington State Convention Center, Seattle. Contact: 800-326-8638.

October

15-20—International Association of Chiefs of Police, Albuquerque Convention Center, Albuquerque, NM. Contact: 703-243-6500.

Mobile Radio Technology

The journal of mobile communications technology

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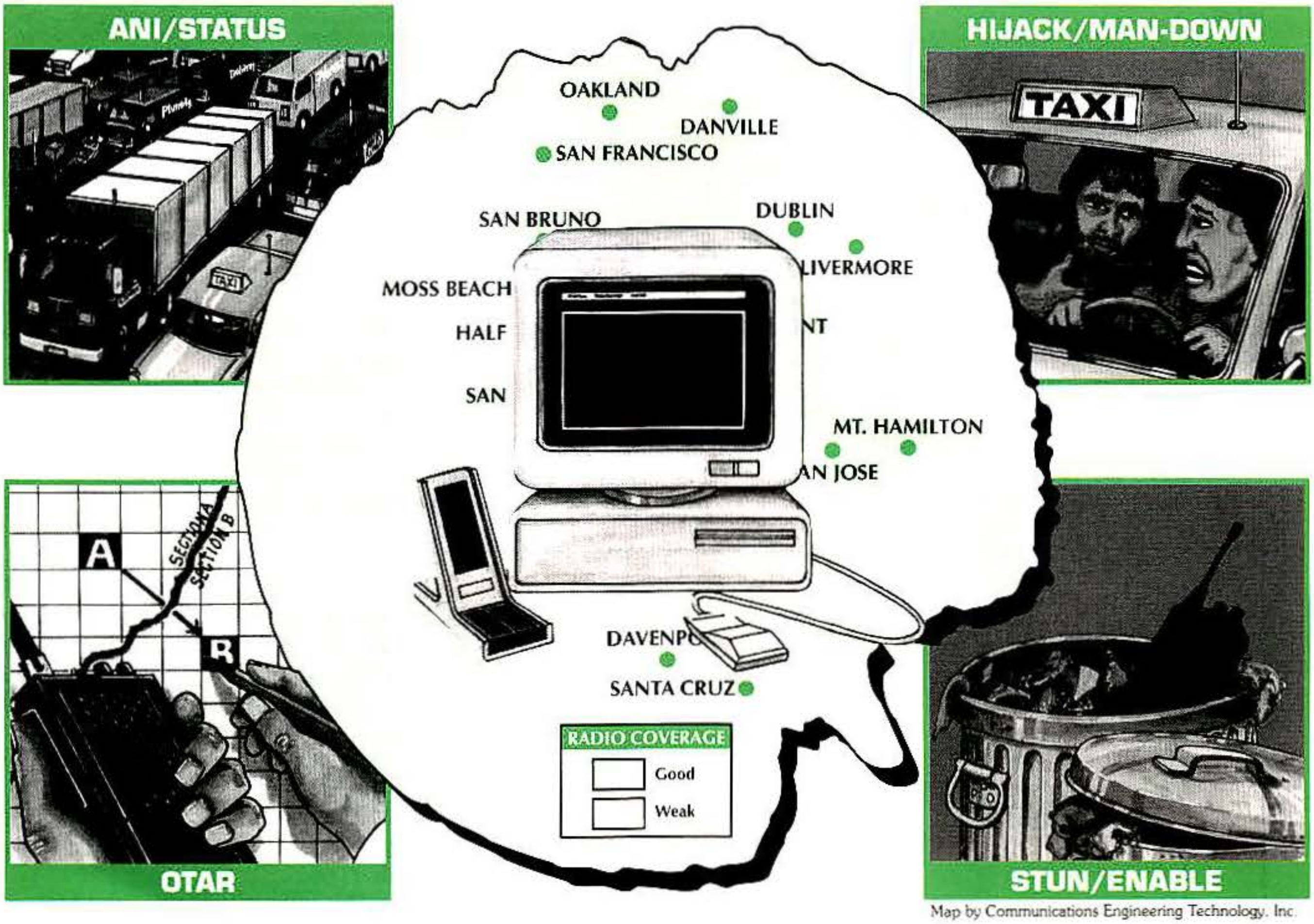

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Circle (7) on Fast Fact Card

Technically speaking

Receiver desensitization

By Harold Kinley, CET

In last month's column, transmitter noise was discussed in some depth.

Receiver desensitization ties in very closely with transmitter noise. Usually, when you have a problem with one, you will have a problem with the other.

Receiver desensitization or *desense* results when a transmitter is operated in close proximity to a receiver that is tuned to a frequency not far removed from the transmitter frequency.

The example in Figure 1 below shows a receiver tuned to 159.120MHz and a transmitter operating at 159.345MHz. Unless sufficient isolation is provided between the transmitter and receiver, the transmitter signal can overload the receiver's front end, seriously desensitizing the receiver and possibly preventing signals from distant mobile units from being heard.

Moreover, the operator may be entirely unaware of a desense problem. It is a silent and often unnoticeable type of interference.

Isolators revisited

In reference to the June column on isolators, an alert reader, Bill Durtler of NovAtel Communications, Calgary, Alberta, found an error or omission that might have caused some confusion.

The June column reads that the return loss at the transmitter should be approximately equal to the combined isolation figures of the cascaded isolators plus the return loss at the output of the last isolator (nearest to the antenna).

Mr. Durtler's letter reads: "Kinley states several times that the return loss is equal to the combined isolation figures of the isolators. Unfortunately, this is not the case."

Mr. Durtler's statement is absolutely correct. The error came from considering only the reflected signal component caused by the mismatch at the antenna and traveling back through the isolator to the input port.

This reflected signal component will be below the incident signal level at the isolator's input port by an amount approximately equal to the combined isolation figures of the isolators plus the return loss at the output port of the last isolator. This assumes that the isolators are properly tuned and otherwise functioning properly.

Nevertheless, there is another reflected signal component at the isolator's input port that is caused by the small mismatch at the input port. Normally, this reflected signal component's amplitude would be much greater than the reflected signal component (caused by an antenna mismatch) traveling in the reverse direction through the isolator.

Because the input port mismatch would produce a much greater reflected signal component traveling from the isolator input port toward the transmitter, it is this reflected signal component that determines the overall return loss between the isolator input and transmitter output.

Technically speaking, both signal components would combine to produce a resultant signal. The resultant signal's amplitude would depend upon the phase relationship of the two signal components.

The bottom line is that the overall return loss at the input port was not considered, and it should have been. Mr. Durtler's point is well taken, and it is hoped that readers of that column will see this correction. I regret the error.

Mr. Durtler goes on to write: "If Kinley's assertion were true, I would be able to get arbitrary return loss, say, for example, 100dB, by cascading the required number of isolators. This would put the precision load manufacturers out of business."

I fail to see this point, because isolators require high-quality loads to function as isolators. Isolators without good-quality loads at each load port are little more than circulators. I fail to see the benefit of such an arrangement—even if...!

—*Harold Kinley, CET*

How much isolation?

To determine how much isolation is needed to prevent receiver desense, it first is necessary to know about the specific receiver desensitization characteristic.

This characteristic usually is found in the form of a graph that can be obtained from the equipment manufacturer on request. If you do not have the manufacturer's data sheet, you can perform the standard Electronic Industries Association (EIA) or Telecommunication Industries Association (TIA) test for *adjacent channel selectivity and desensitization*. (See Figure 2 on page 56.)

Suppose that the receiver desense graph for the receiver in Figure 1 shows that, at a frequency separation of 225kHz (159.345MHz − 159.120MHz), the receiver selectivity provides 90dB of *immunity* to receiver desense.

This immunity is referenced to a receiver input level of 0.35μV (−116dBm) for 12dB SINAD. This specification means that, for the offending transmitter signal to cause receiver desense, it must be 90dB stronger than the reference input level of −116dBm (0.35μV), which translates to a level of −116dBm + 90dB = −26dBm.

(continued on page 56)

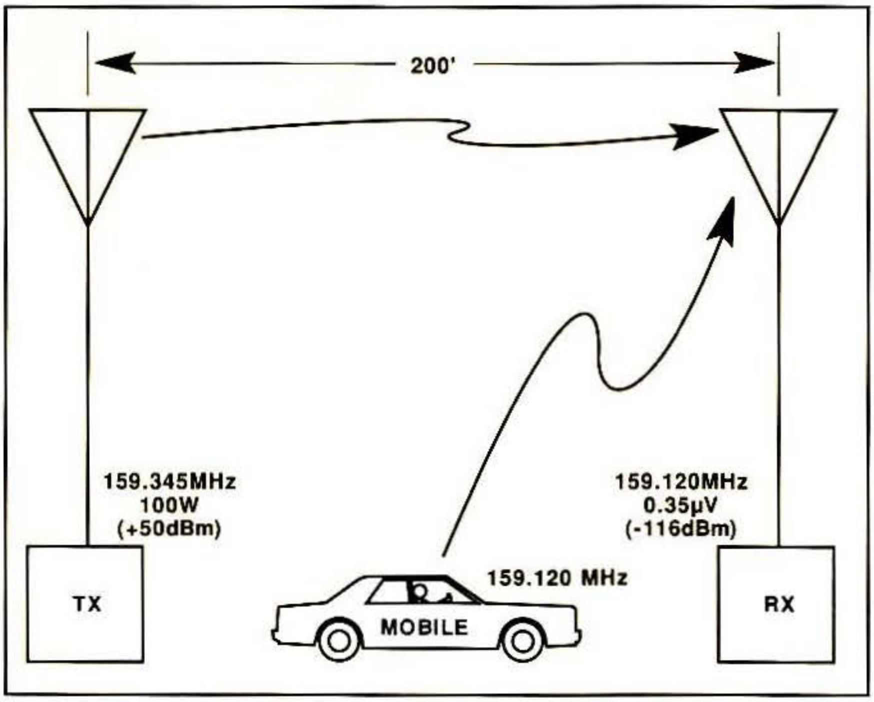

Figure 1. The transmitter, which is operating just 225kHz above the receiver frequency, is overloading the receiver's front end, resulting in desensitization. The weaker mobile signal may not get through in the presence of the stronger transmitter signal. Sufficient isolation must be provided through antenna spacing (vertical or horizontal), special filters to suppress the strong transmitter signal down to a non-interfering level, or a combination of the two.

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

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RF radiation guidelines for communications sites

Evidence of the RF radiation levels in and around one's facility, plus posted warnings in those areas exceeding the guidelines, could provide significant protection from injury claims from RF radiation.

By Raymond C. Trott, P.E.

The wireless revolution is continuing at a phenomenal pace.

Practically all new radio systems being implemented or planned are multi-transmitter systems requiring sometimes hundreds of transmitter sites over wide regional areas and across the nation. These systems have familiar acronyms: SMR, ESMR, RCC, PCP, and VLS.* Add cellular systems to that list.

To support these systems, existing antenna sites are being saturated with new antennas, new building sites are being developed, and many new towers are popping up all over.

Because these antenna facilities are easily visible to nearby inhabitants, sometimes members of the public worry about the effects these installations could have on their environment and their community's health. Concerns of these type were made public during the cellular phone "cancer scare" in January 1993. The cellular industry was put on trial for a few days, and the news media gave the matter extensive coverage.

The construction of towers and issuance of tower permits all over the country are being blocked by local citizens concerned about the long-term effects of electromagnetic radiation from neighborhood communication towers. Cellular towers are targeted in particular because of their connection to the portable cellular phone cancer scare.

Recently, residents in a small Puerto Rican village were successful in seeking an injunction halting construction and use of a cellular communication tower. In this case, the microwave dish, which radiates a signal thousands of times below the radiation standards for safety, was the target of the small, 432-person community.

The construction of towers and issuance of tower permits all over the country are being blocked by local citizens concerned about the long-term effects of electromagnetic radiation . . .

Since 1988, the concern of residents near a mountaintop communications site in California has forced the site managers to spend hundreds of thousands of dollars investigating and debating the environmental condition of the site.

These are just two examples out of perhaps many where the public is forcing communications site owners and managers to be aware of and to adopt an effective radiation hazard management program.

RF radiation standards history

In 1969, the National Environmental Policy Act required all federal agencies to consider the quality of human environment in all regulatory decisions.

The FCC met this requirement in 1985 when it adopted RF radiation exposure guidelines using standards developed by the American National Standards Institute (ANSI) in 1982. These standards became known as ANSI C95.1-1982.

Since January 1986, broadcast stations, in their applications for new or modified facilities, must certify that these FCC RF radiation protection guidelines are met. This ensures that humans will not be exposed to RF radiation beyond the guidelines. Generally, land mobile stations were not required to comply.

In 1991, the Institute of Electrical and Electronic Engineers (IEEE), revised the ANSI C95.1-1982 standard. Whereas the 1982 standard covered all humans under one broad classification, the 1991 standard (IEEE C95.1-1991) classified exposure into controlled and uncontrolled groups. (See below)

The following year, ANSI adopted the 1991 IEEE standard, which now is known as ANSI/IEEE C95.1-1992. Finally, in April of this year, the FCC released a *Notice of Proposed Rulemaking* (NPRM) proposing to amend its 1985 guidelines and adopt

*SMR is specialized mobile radio; ESMR is enhanced specialized mobile radio; RCC is radio common carrier; PCP is private carrier paging; and VLS is vehicle location system.

Trott is president of Raymond C. Trott Consulting Engineers, Irving, TX, a company that provides RF radiation measurement services to ensure compliance with radiation exposure standards. He is a Fellow in the Radio Club of America.

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the ANSI/IEEE C95.1 guidelines.

Environment classification

The big difference between the 1982 and 1992 guidelines is the classification of controlled and uncontrolled environments.

Controlled environments are areas where there is a potential for exposure to people who are aware of the potential for exposure. A good example would be a radio technician working in an area close to an RF radiation source. The area of concern could be an equipment building housing transmitters either on the ground or on a tower or a building top.

Uncontrolled environments are areas where there is a potential for exposure to individuals who have no knowledge or control of their exposure. An example would be public areas or even residences near broadcast facilities where the public could be exposed to RF radiation.

The ANSI/IEEE and proposed FCC guidelines are based on the maximum amount of RF energy that a human can absorb safely. Although the standards limit the rate of body absorption, designated as specific absorption rate (SAR), this limit is also shown in terms of plane wave equivalent power density (mW/cm^2). In this way the fields can be measured conveniently to determine exact levels.

The standards for the controlled environments are generally $1.0mV/cm^2$ in the low end of the land mobile spectrum with an increase to $3.0mV/cm^2$ at 900MHz. These values are based on a six-minute period for which exposure is averaged. Thus, where the exposure is for three minutes, the exposure limit would increase to $2.0mV/cm^2$ from $1.0mV/cm^2$.

For uncontrolled environments, the standards are five times more restrictive or $0.2mV/cm^2$ at the low end of the land mobile spectrum, increasing to $0.6mV/cm^2$ at 900MHz. Here the average exposure time is 30 minutes.

What can site owners/managers do?

The FCC NPRM proposes more strict guidelines in the amount of RF exposure permitted.

Some facilities excluded in the 1982 guidelines may not be excluded under the new proposed guidelines. Most of the 1982 exclusions were low-power land mobile stations.

It is likely that the facilities with many transmitters—especially those with the high-power paging transmitters—will be in the new guidelines.

Now may be the time for those site managers to establish radiation hazard management programs. These programs will identify areas with high RF levels and enable the manager to protect his employees and the public from excessive RF radiation.

Evidence of the RF radiation levels in and around one's facility, plus posted warnings in those areas exceeding the guidelines, could provide significant protection from injury claims from RF radiation.

New modem, Bessel filter enable 2,400-baud paging

Inexpensive upgrades to existing infrastructures boost radiopaging system throughput from 1,200-baud to 2,400-baud, doubling the channel capacity. Performance statistics of 1,200-baud and 2,400-baud pagers are equivalent.

By Irene Moore, Mark Witsaman and Mike McCabe

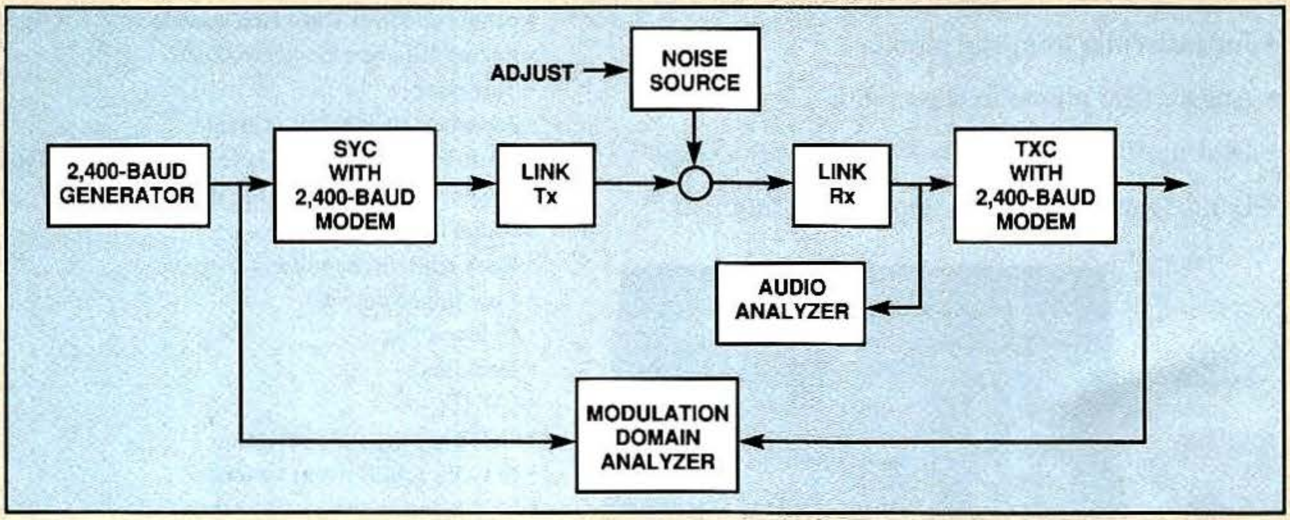
If there are three words that radiopaging service companies savor when it comes to transmitting paging messages, they are "faster," "better" and "inexpensive."

When a large paging company asked for cooperation in a project to increase the speed at which messages are transmitted, the result was a joint project to develop an inexpensive infrastructure upgrade to transmit POCSAG messages at 2,400 baud.

Transmitting paging messages at 2,400 baud provides several advantages. It doubles the channel capacity compared to existing 1,200-baud systems, minimizes regenerative paging

Moore is director of corporate communications at Glenayre-Atlanta. Witsaman is engineering vice president and McCabe is product manager, QT RF products, at Glenayre-Quincy. Moore is a member and McCabe is a Fellow in the Radio Club of America.

Testing the 2,400-baud modem's performance



To verify the 2,400-baud modem's performance, a laboratory test setup as shown above was designed.

The modulation analyzer was used to determine the modem's jitter characteristics. Bit errors also could be detected.

The data source was a function generator sending a 1 0 pattern at 2,400 baud. The SYC contained the 2,400-baud digital signal processing (DSP) modulator, and the TXC was fitted with a 2,400-baud demodulator.

Data were sent through an RF link using a standard 900MHz link transmitter and receiver. Noise on the RF channel was controlled and channel quality was determined in terms of SINAD and total harmonic distortion using an audio analyzer.

The histograms in Figures 1, 2 and 3 were generated by the modulation domain analyzer. No bit errors were sensed on any of the test runs shown. The x-axis on each histogram shows total delay through the system. The distribution along the axis is a normal distribution, and the mean, peak-to-peak variation and standard deviation were derived easily.

and improves operation of shared channels.

In addition, 2,400-baud pager technology is a natural extension of 1,200-baud. As a result, the development cycle for a 2,400-baud pager and infrastructure was shortened, and the risks in evolving the high-speed format were minimized. Unlike the European Radio Messaging System (ERMES), 2,400-baud paging can be implemented with minor modifications to existing base station equipment.

As often is the case when innovating or improving technology, there were technical and financial challenges to be answered. When considering the financial aspects of 2,400-baud paging, the goal was to use the customer's existing paging system infrastructure and to provide inexpensive upgrades.

On the technical side, there were several considerations. It was obvious that a new control system had to be developed or the present control system modified to handle 2,400-baud paging. The primary reasons for this requirement were the tighter tolerances necessary to meet the POCSAG specifications at the higher speed.

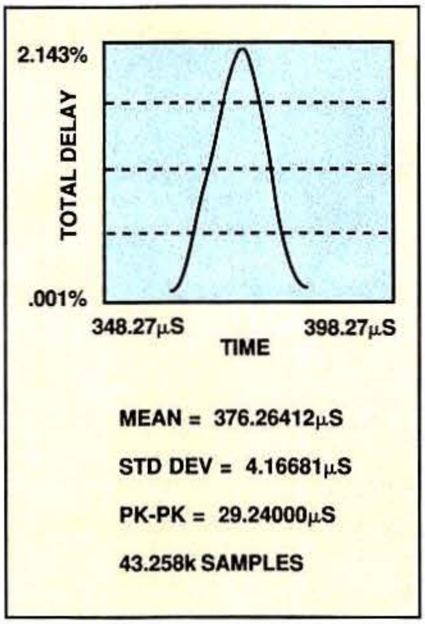


Figure 1. Histogram for 13dB SINAD radio link to transmitter modem, 2,400 bps square wave, 22% total harmonic distortion at 1,000Hz. Note: The 13dB SINAD test was conducted as a worst-case illustration. Link design at this level is not recommended.

For example, at 1,200-baud paging, the bit width is approximately 830µS. The POCSAG specifications allow only one-quarter of the bit width, or approximately 200µS, to be used for the delay-jitter budget, which includes factors such as isochronous distortion including jitter, delay error and multiple transmitter overlap.

Because 2,400 baud is twice as fast, the bit width is halved to 415µS. Using the same POCSAG specification, only one-quarter of the bit width, or 104µS, can be used for the delay-jitter budget.

One of the simulcast characteristics that cannot be controlled is the subscriber's location in the overlap zones. As an example, in a 10-mile overlap zone covered by radio signals that travel at 5.4µS per mile, there is a possible delay error of 54µS caused by the subscriber's location in the overlap zone. This reduces the jitter

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budget and leaves only 50 microseconds for all the other factors, such as modem jitter, distortion, delay errors and clock drift.

To meet this challenge, a new high-speed modem had to be developed. This modem not only had to reduce the jitter it introduced into the system, but it also had to be asynchronous. Previously, there was no asynchronous modem available for paging speeds higher than 1,200-baud paging.

To provide for these advances and for future flexibility, digital signal processing (DSP) was used to develop the new modem. The modem allows only 28µS of total jitter at 15dB SINAD for both 1,200-baud and 2,400-baud paging.

Well below the allowable tolerances, the new modem reduces jitters and improves the performance for 512-baud, 1,200-baud and 2,400-baud pagers. In other words, it makes them more reliable by consuming less of the delay-jitter budget.

Some of the other functions incorporated into the new high-speed modem include:

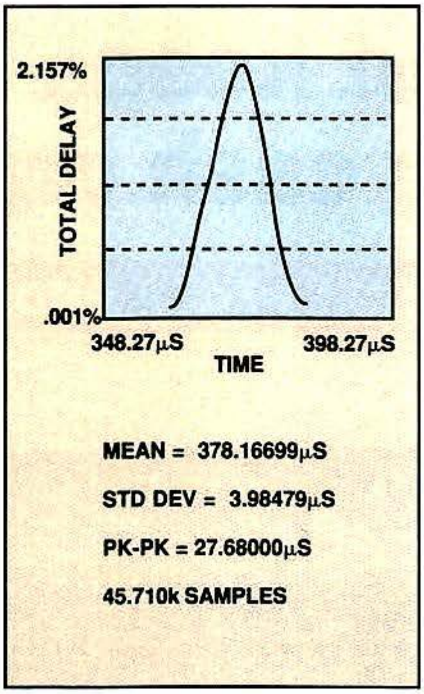

Figure 2. Histogram for 15dB SINAD radio link to transmitter modem, 2,400 bps square wave, 17% total harmonic distortion at 1,000Hz.

- ▶ a data speed of 0bps to 3,000bps.
- ▶ multi-ary continuous phase frequency-shift keying (MCPFSK) modulation.
- ▶ an improved bit error rate (BER) performance for superior operation on existing links and reduced jitter on demodulation.
- ▶ a peak worst-case jitter of ±14µS and a typical jitter of ±4µS measured on a 15dB SINAD link.
- ▶ improved audio processing for better performance in low SINAD environments.
- ▶ better than 10^{-6} BER at 15dB signal-to-noise ratio.

Another complication that had to be resolved was decreasing the rise time for 2,400-baud paging.

The audio filters previously employed in the exciter provided a rise time of 150µS when going from a data low frequency to a data high frequency. This rise time is marginal for 2,400-baud paging, so to improve the

rise time, a new 10-pole Bessel filter was developed. This new filter is an outcome of the ERMES specifications. It provides a rise time of only 88µS, and its output remains inside the FCC-specified occupied bandwidth mask.

The 88µS rise time translates into better pager performance in both the overlap zones and the fringe areas. Overall, it improves performance and enables more accurate data recovery.

Naturally, there were some early concerns about the possibilities for decreased pager sensitivity and battery life. There also were some doubts as to the practical operation of 2,400-baud paging working with real-world noise and fading in a multipath reflection environment.

Several tests were conducted to improve the 2,400-baud system enhancements' effectiveness.

In a laboratory, a miniature test site was set up to simulate a small paging system. During the transmission, a device that simulates on-line noise at different levels was placed between the link transmitter and the link receiver. A modulation domain analyzer was used to evaluate the 2,400-baud paging system's performance. Figures 1, 2 and 3 on pages 16, 18 and on the left, respectively, show the modem performance at 13dB SINAD, 15dB SINAD and 20dB SINAD.

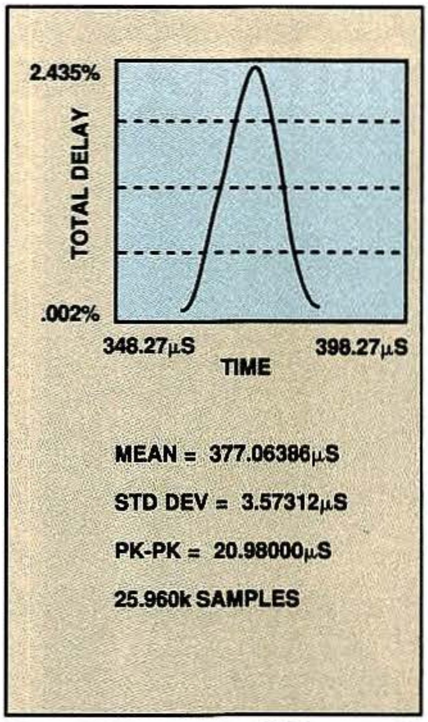

Figure 3. Histogram for 20dB SINAD radio link to transmitter modem, 2,400 bps square wave.

In addition to the comprehensive lab trials, three different *real world* test sites were selected. All of these tests were conducted by collective teams. Half were engineering employees from Glenayre and half represented the customer's technical staff.

The tests were conducted in three phases.

In the first phase, before the infrastructure was changed, the test teams established a base line. They drove around the city with an assortment of 1,200-baud numeric and alphanumeric pagers. Test pages, composed of short numeric and alphanumeric messages and of long alphanumeric messages, were sent at 1-minute intervals.

The teams tested pages in remote

locations on the paging system's fringe areas, in difficult building interior locations and in multiple-transmitter overlap zones. The performance results were logged carefully and analyzed.

Next, the infrastructure upgrades were installed, including the modem. The teams then took the same group of 1,200-baud pagers used in the first test and some 2,400-baud pagers and set off across the city. Once again, the test pages were duplicated and sent at continuous intervals. The teams collected data from more than 10,000 pages and measured more than 4,000 data points in the simulcast coverage area.

The first test was conducted with a single transmitter under local control

The teams collected data from more than 10,000 pages and measured more than 4,000 data points in the simulcast coverage area.

at the University of Mississippi in Oxford, MS.

The second test site was at St. Louis, a "friendly" simulcasting environment because the terrain is relatively flat and the downtown area does not have too many large buildings. This location provided the opportunity to test a simulcast, 4-transmitter system using an advanced simulcast control package.

The third test site at Denver included transmitters on mountaintops and on downtown buildings. The diverse geography provided much more complicated overlap zones. The Denver system had five transmitters with a second-generation digital control unit.

The actual testing was done in exactly the same way at all the sites. The teams established a base line, changed the infrastructure and collected more data.

The results were the same for the three test sites. There was no significant difference in 1,200-baud and 2,400-baud sensitivity in the field test. The 2,400-baud pages worked even in

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heavily loaded, multiple-format simulcast environments using both numeric and alphanumeric POCSAG paging formats. The pager sensitivity, whether 1,200-baud or 2,400-baud, showed little or no difference, and the pagers exhibited comparable battery life.

According to the mathematical models, the 2,400-baud pagers should under-perform the 1,200-baud pagers; nevertheless, a variety of real-world tests proved differently.

The reason is because the mathematical models are based on Gaussian noise distribution, and with the RF environment's burst noise, the shorter 2,400-baud paging message packets increase the probability of successful reception despite burst noise. Thus, the real-world test does not match the mathematical models. The same argument holds true for a fading model.

. . . despite mathematical models to the contrary, the real-world tests prove that 2,400-baud performance actually is comparable to 1,200-baud performance.

In other words, despite mathematical models to the contrary, the real-world tests prove that 2,400-baud performance actually is comparable to 1,200-baud performance. In addition to doubling channel capacity compared to existing 1,200-baud systems, it doubles the page throughput and minimizes regenerative paging.

Plus, it can be achieved with inexpensive upgrades to the existing paging infrastructure. With at least one company's systems, the upgrades cost about $1,000 per site, and they are compatible with two earlier generations of control equipment.

With 2,400-baud paging, carriers once again can savor the three words they like the most, *faster, better* and *inexpensive*, and add two more, *2,400 baud.*

Comparisons of analog and digital cellular

The popular belief is that digital modulation combined with signaling protocol and call processing performs better in a fading environment than analog. Although this often is the case, it is not generally so.

By Terry S. Cory, P.E.

The additional subscriber capacity offered by time-division multiple-access (TDMA) digital cellular telephone service does not come without effort and expense on the part of system operators.

The cellular system RF infrastructure must be continually improved to minimize the *location variability* for mobile operation and to avoid degraded call quality compared with analog FM systems. With a high-quality RF infrastructure, a carrier-to-interference (C/I) ratio close to the 5dB-6dB that TDMA digital system manufacturers advertise may be realized.

Call quality is affected more in the *threshold signal region* for digital than for analog. To assess the comparison, the threshold characteristics of both analog and digital must be evaluated in a fading signal environment.

TDMA digital cellular operation offers three times as many channels as current analog FM, along with the possibility of about a 5dB improvement in C/I ratio performance. The ultimate call quality for high C/I ratios in a system environment is expected to be about the same as for current mass-produced FM receivers in the same environment—a baseband audio signal-in-noise-and-distortion (SINAD) of as much as about 35dB.

For the future, the digitized voice signals allow for processing that would optimize call quality further, once considerable system operating experience has been gained.

The TDMA format probably is the best choice to sustain operating systems during the impending technology transition, which is likely to take years.

Dual-mode operation

Cellular carriers that offer TDMA digital service continue to support analog FM service, too. Subscriber equipment manufacturers offer dual-mode telephones so customers can take advantage of TDMA digital service where it is available and use analog FM service where it is not.

For the time being, the mixture of TDMA digital and analog FM service on the same systems gives an additional C/I benefit because a given time-division multiplexed channel only is "on" a third of the time. Eventually, where systems become entirely digital and operate near their capacity, the

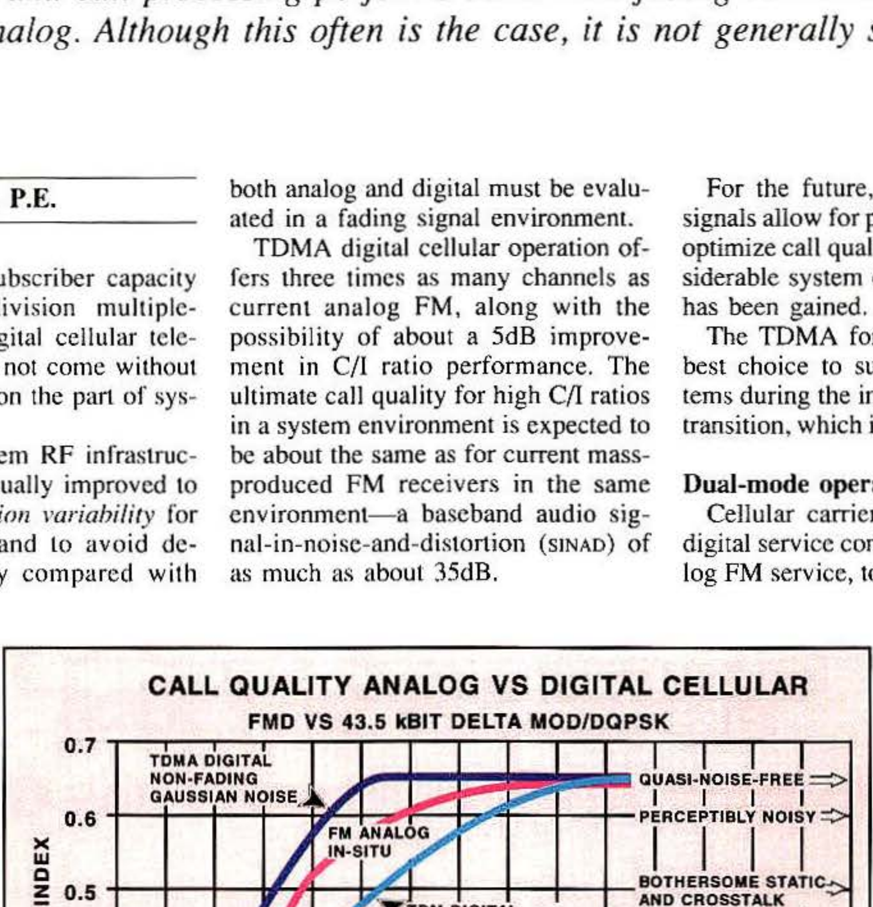

Figure 1. Call quality curves for analog and TDMA digital cellular telephone service comparing the articulation index with various carrier-to-interference (C/I) ratios show that TDMA may be 5dB-6dB better than analog FM when there is little fading and as much as 2dB-3dB worse when the fading is deep. Careful RF infrastructure implementation minimizes fading.

Cory is a radio and telecommunications consulting engineer with Analink Systems in Plano, TX; tel. 214-985-0006.

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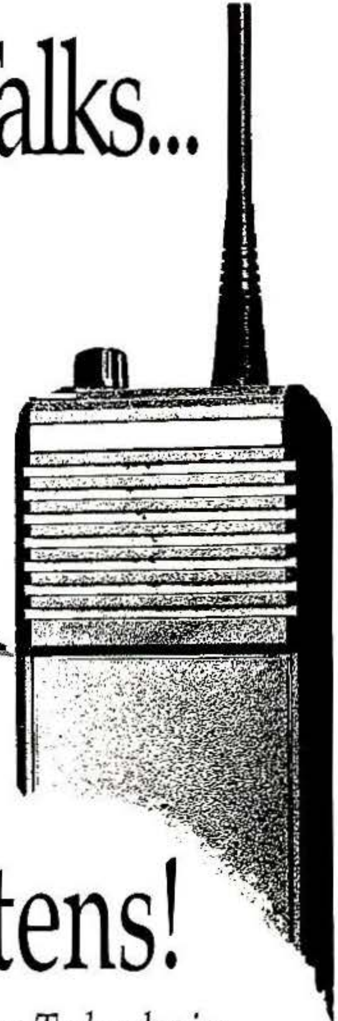

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additional 8dB of peak power per cell will eliminate this interim advantage.

Achieving these call-quality benefits that stem from high C/I ratios depends on continually improving the RF system infrastructure. Although the use of digital modulation produces optimum results with the relatively narrowband cellular radio channel, it does so only if the signal variation with time is minimized.

Perhaps this variation is minimized automatically for the essentially fixed operation of portable telephones that are not being used in vehicles in motion. In vehicles, though, the location-variable characteristics of radio propagation may degrade the digital call quality even more than for analog.

The most graphic means of displaying comparative performance is to depict threshold curves for typical receivers. A typical call quality range of expectations for analog and digital transmission is shown in Figure 1 on page 24, where baseband SINAD has been interpreted as articulation index. Note the range in digital performance between fading and non-fading cases, and that the fading case assumes dual-diversity reception.

Figure 1 shows that the digital signal in the fading environment may be 2dB-3dB worse than for analog FM. One might ask whether the FM characteristic is affected similarly by fading and interference. The answer is yes.

The most graphic means of displaying comparative performance is to depict threshold curves for typical receivers.

The FM curve shown in the figure typifies performance achieved in the system environment; that is why it was chosen as the reference curve for this comparison. The astute technologist will recognize that Figure 1's FM curve approximates the curve that would be expected for narrowband FM with a modulation index of just greater than unity, rather than the curve for a modulation index of 4—as actually is used in the analog design.

The realizable FM curve is partially a result of the channel characteristics and partially a result of using "cost-effective" equipment in an interference-limited system. The FM characteristic degrades or improves "vertically" on the graph as expressed as the achievable SINAD or articulation index for good signals, whereas the digital characteristic degrades or improves "horizontally" on the graph and, therefore, is more sensitive to the C/I ratio

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(or threshold extension).

Digital modulation

Figure 1's digital curves are for delta-modulated differentially coherent quaternary phase-shift keying (DQPSK), assuming an effective signaling rate of 43.5 kb/s, a 6dB pre-emphasis and de-emphasis, and a fixed sampling and quantization process. Adaptive sampling algorithms and data coding vary the effective transmission speed and, thus, extend or diminish the threshold horizontally in the same way they extend or diminish the effects of propagation variability, as was described above. Higher signaling rates (more bits/hertz) coupled with coding lower the threshold (move the curve to the left).

The popular belief is that digital modulation combined with signaling protocol and call processing will perform better in a fading environment than analog. Although this often is the case, it is not generally so.

In narrowband systems with signals from a moving mobile unit, there are aspects of fading, especially in urban areas, that defy mitigation. In particular, sometimes diversity reception is relatively ineffective in overcoming fading.

Space diversity reception using two receiving antennas works well against fading caused by specular multipath and scintillation.

Diversity reception

Space diversity reception using two receiving antennas works well against fading caused by specular multipath and scintillation. In fringe areas, signal variability is caused by diffraction and scattering from large objects that block or diffract the signal. Close to the cell site, signal variability often occurs because of nulls in either the primary or secondary radiation patterns of the antennas.

Much of the location variability can be eliminated by assuring line-of-sight coverage between the cell-site antenna and the mobile and by assuring that the antenna radiation pattern to the mobile including ground reflections (secondary pattern) contains no nulls.

If fading happens despite these precautions, virtually no degree of digital signal processing will make the threshold characteristic as good as it is for a comparable, unprocessed, non-fading signal in laboratory noise.

For example, if the signaling rate is doubled to 87 kb/s and if half-rate coding is used, the digital curve shifts to the left to a position roughly tangent to the FM curve at its knee. Near the upper SINAD rail, this latter curve shows

a 5dB-6dB benefit over FM.

Final general observations

The usual way to improve threshold extension while mitigating signal variability effects with digital signal coding is to use wider bandwidths for digital modulation than for analog. This method is exemplified most vividly by the more critical line-of-sight path clearances required for digital microwave compared to analog microwave.

The digital data rate in a dispersive channel always is less than the bandwidth required for analog transmission because of the digital format overhead required. Thus, generally, the threshold characteristic for digital modulation has less slope than for analog modulation. The result is that the "FM capture effect" is not pronounced with digital voice.

It follows that the observed call quality in the presence of a decreasing C/I ratio is likely to resemble AM more than FM. Because of practical quantization limits, the threshold characteristic's upper SINAD rail is lower for AM than for FM, so the narrowband channels are not quite *toll quality* (landline telephone quality).

. . . generally, the threshold characteristic for digital modulation has less slope than for analog modulation.

Speech compression possibilities of M-ary PSK modulation in white noise are difficult to approach in a fading signal environment because of urban radio propagation characteristics.

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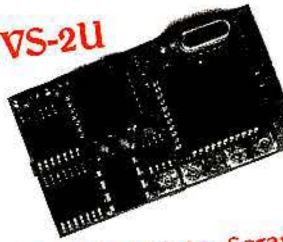

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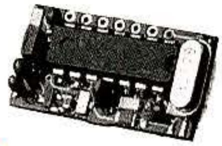

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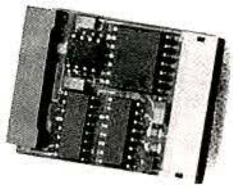

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Improve indoor communications with radiating coaxial cable

The ease of installation, cost savings in material and labor, and improved RF coverage as documented in a factory test make radiating cable the clear choice for indoor RF communications transmission.

By James J. Ford

Objective: *effortless indoor communications installations with complete coverage.*

Well, not really *effortless*, but compared to point-source antennas, radiating cable greatly reduces costs, labor and frustration.

Mobile radio communications are inhibited by limited propagation through metal or underground structures. In fact, a common problem for a municipal communications system is lack of coverage. A simple solution is to provide a path for the radio signal to reach the area with poor radio coverage. The use of radiating cables can help to reduce installation problems and costs.

Wireless indoor communications through the use of a point-source antenna system in an enclosed area tends to diminish signal propagation through walls and in and around metal structures. A radiating cable is an RF transmission line designed to couple the RF energy propagating its length to the environment.

In doing so, it works as a continuous antenna that is more efficient in providing RF coverage in enclosed areas such as tunnels, mines, metal-hulled ships and metal-framed buildings.

To enhance communications for Transit Police in subways, the New York City Transit Authority has selected radiating cable that provides coverage in areas where RF propagation from a point source antenna is ineffective. The current project will use more than 65 miles of cable to cover the IND Division, systemwide, through the boroughs of Brooklyn, Manhattan, Queens and the Bronx.

Covering limited areas

The low levels of energy emitted by radiating cables makes them ideal for achieving radio coverage in limited areas, allowing for frequency reuse. This is important because of the many competing demands for RF spectrum that make efficient spectrum use a pressing concern.

Where reliable communication is a safety concern, radiating cables reduce or eliminate dead spots, providing the necessary radio coverage when it is needed the most. Radiating cable is used extensively in the New York subway system by Transit Police to provide reliable communications. Whether the use is in public safety or in reducing business costs, radiating cables provide a great benefit.

Wireless local area networks (LANs) transmit data, correspondence, and voice messages rapidly and efficiently between stations in offices, factories and warehouses. Many wireless LANs exploit the characteristics of radiating cable to support these communications.

Reconfiguration and relocation of equipment and employees can be

Ford is product engineer for radiating cable products at Times Microwave Systems, Wallingford, CT.

achieved more quickly and at a lower cost with radiating cable. Wireless connections also allow portable equipment to be used while remaining interconnected to the network.

Selecting distribution

For radio communication in an enclosed area, an antenna or multiple antenna sites will provide some level of radio propagation. The following information can be helpful in selecting what type of signal distribution technique to use.

Many antenna manufacturers are promoting wall-mountable antennas that are fairly inexpensive. In fact, an antenna may be ideal for small indoor areas or where there are no obstructions.

On the other hand, if there are obstructions in or around the path of the radio signal, adequate coverage may require a more sophisticated approach.

Comparisons

Factory measurements were made to evaluate the performance of radiating cable compared to indoor antennas. The measurements were made in my employer's main manufacturing area, which is 200 feet by 300 feet.

Two quarterwave monopoles were chosen to represent the point-source antennas. These antennas were fed by a 0.500-inch coaxial cable with a smooth aluminum outer conductor to make the use of the couplers easy.

The installation crew that installed the aluminum-sheathed coax and the radiating cable for the test had experience installing electrical conduit, phone lines and datacom lines. The only special instructions given were that both cables for our test could not be bundled with any existing cables and had to be clamped in place separately.

For the test, measurements were performed at 900MHz. The configuration of the first system consisted of the two quarterwave monopoles mounted near the ceiling and fed by 0.5-inch aluminum-polyethylene foam-dielectric cable with a solid, smooth outer conductor coax. This type of cable was selected because it is intended to have the best performance with the available taps (couplers).

The monopoles were connected to the feedline by a 16dB and a 10dB tap. The lengths of coax used were 130 feet to the first tap, 150 feet between taps within the test area and 300 feet after the second tap to the third tap in a separate building (total length 580 feet).

Test configuration

Figure 1 on page 38 shows the layout of the building where the tests were conducted. The RF signal source was placed at the far left end of the building, and both systems were fed at the same point. A wiring closet was used to store the equipment during this test.

The attenuation between the first two taps was 5.4dB. The coupling values of the taps were selected to

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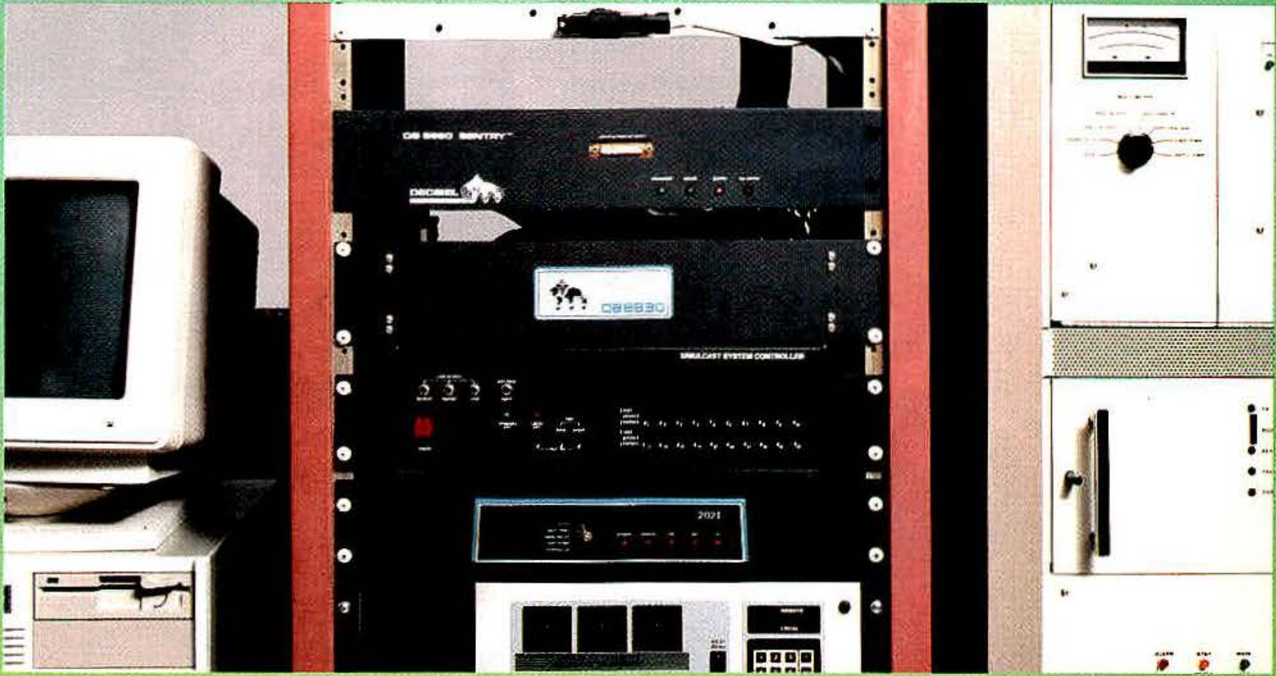

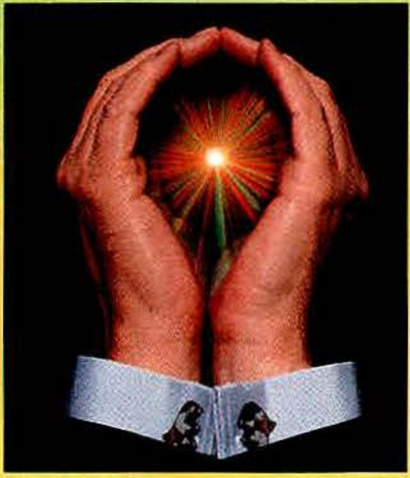

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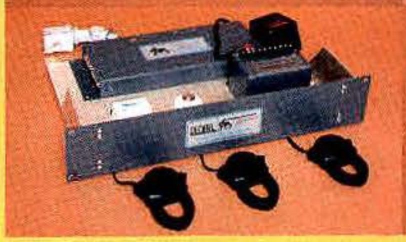

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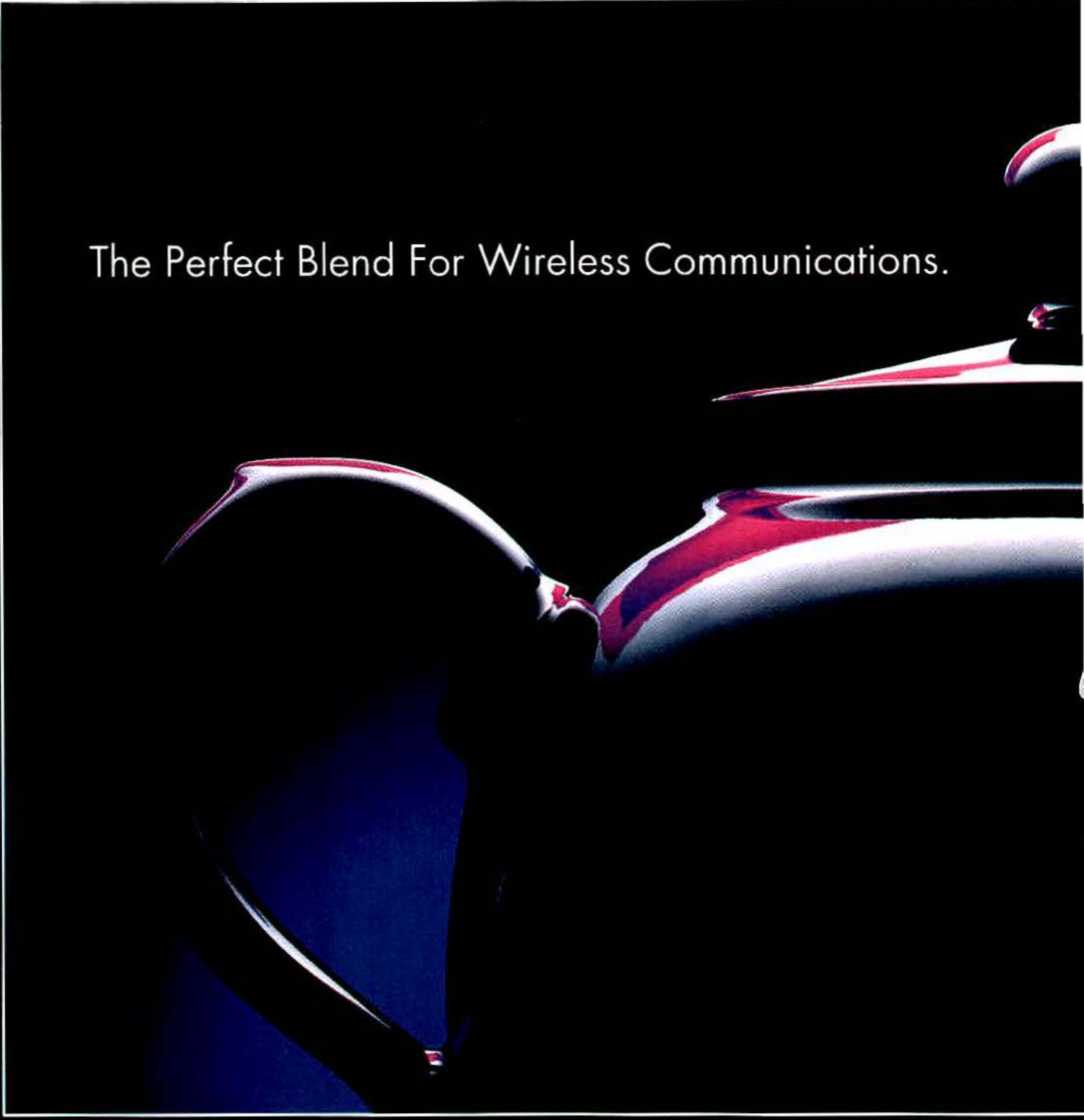

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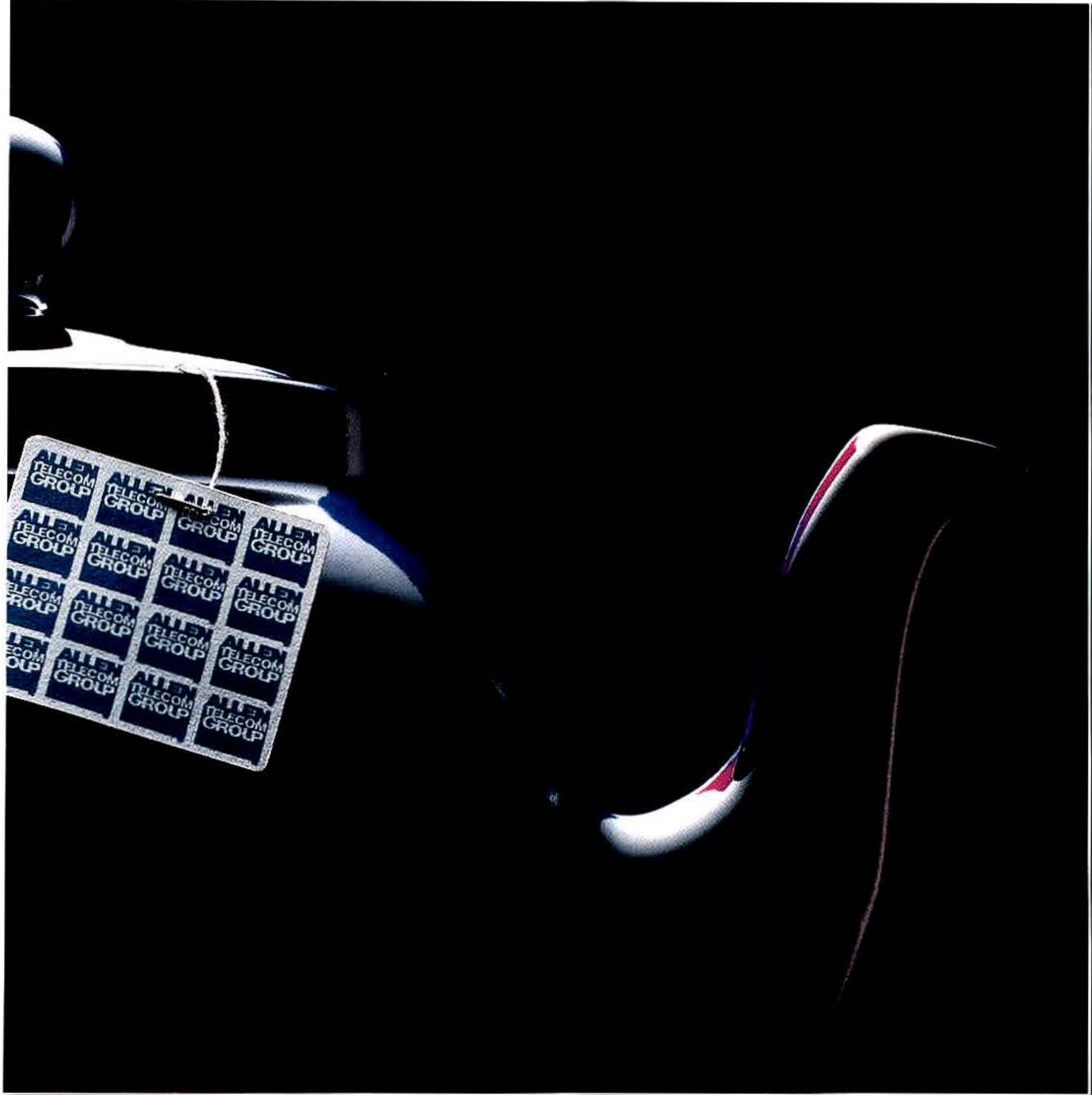
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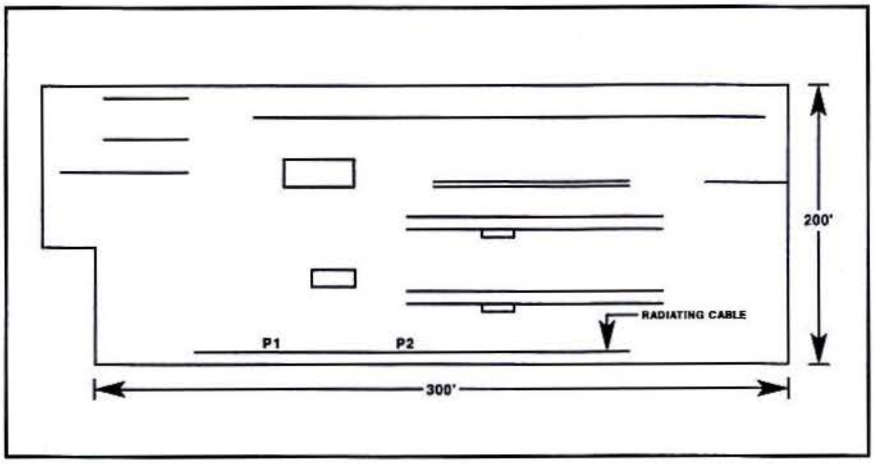


Figure 1. In the building where the tests were conducted, the RF signal source was placed at the far left end, and the radiating cable and point-source systems were fed at the same point. A wiring closet was used to store the equipment during this test.

provide equivalent radiated power at each of the monopoles. The monopoles were configured this way to function as part of a distributed antenna system that would also feed an area beyond our test area with equivalent signal strength.

Only the first two antennas in this area were evaluated. The third tap was in an adjacent building and was terminated in a 50Ω load for this test. The power level at the third tap was +10.6dBm.

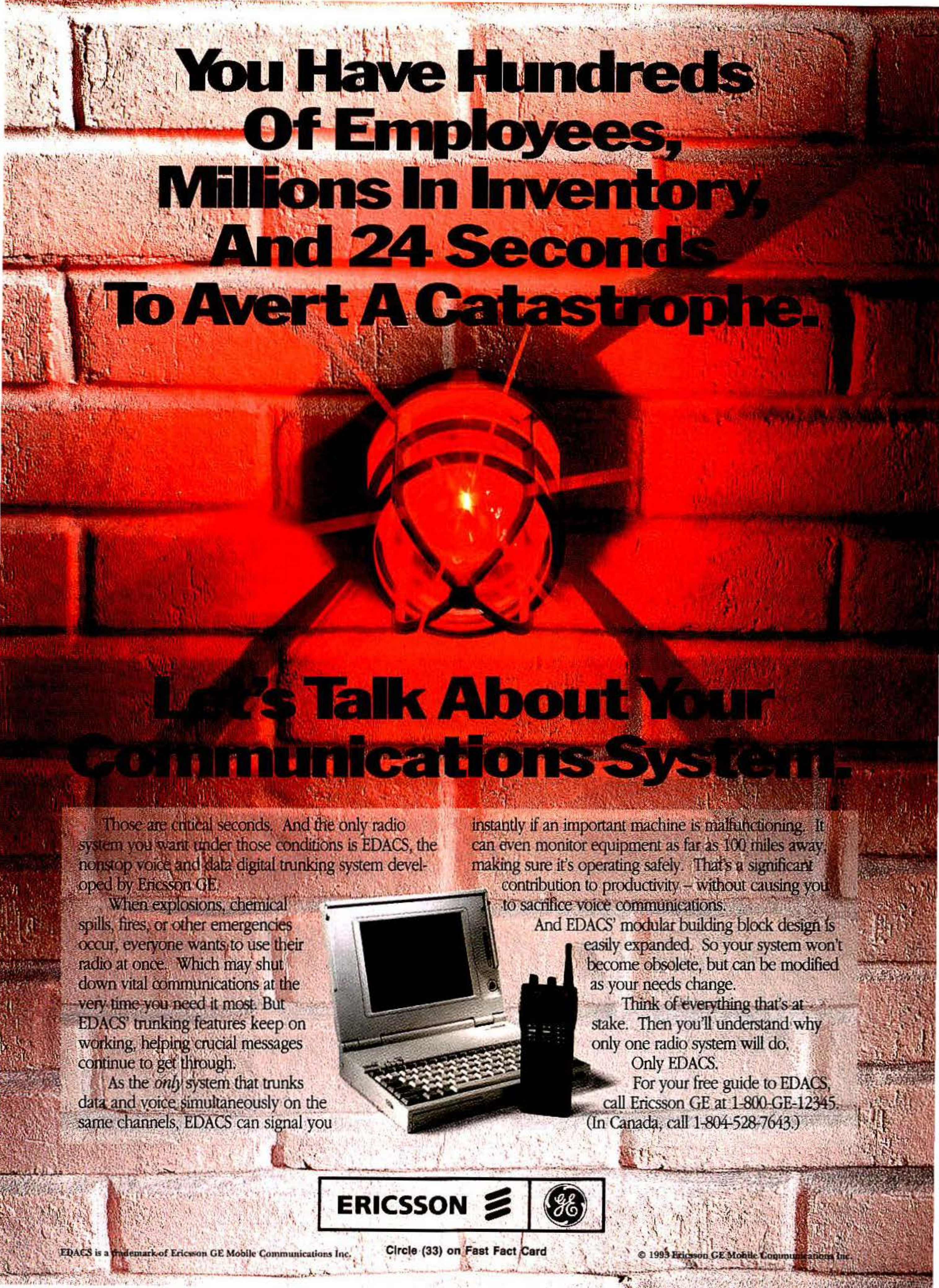
Labor difference

Installing the cable on the factory ceiling took twice as long for the aluminum sheathed coax as it did for the radiating cable. Additional labor and materials costs were incurred in using the aluminum-sheathed coax because of the required taps (couplers), mounting plates and monopoles, none of which is required to install radiating cable.

The flexibility of the same size radiating cable made it much easier to manipulate throughout the installation and contributed even further to its cost-effectiveness.

The radiating cable was installed in place and was measured for loss. The loss was 13.2dB. This test was performed easily, and no other installment verification tests were necessary. To help to understand the signal levels, Figure 2 on page 40 shows the loss budget for each system.

The signal received by a halfwave dipole was measured at 17 locations around the manufacturing area. The value used is the average of 10 values taken evenly over a 20-foot length. The



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Tx → 4dB → –16dB Tap → 5.4dB → –10dB Tap → 10dB → 0dB Tap

Tx	4dB cable loss	–16dB Tap	5.4dB cable loss	–10dB Tap	10dB cable loss	0dB Tap
+30.0dBm		+10.0dBm monopole		+10.6dBm monopole		+10.6dBm monopole

Loss Budget for Distributed Antennas

Tx .... 13.2dB loss .... 50Ω Load

+30.0dBm .... +16.8dBm

Loss Budget for Radiating Cable

Figure 2. These are the loss budgets for the radiating cable and point-source systems.

locations of the measurements were identical for each signal distribution technique.

The receive dipole was held with horizontal polarization. Although recent investigations in wireless communications that have compared polarizations for antennas show vertical linear to be optimal, for convenience, horizontal polarization was used in this test. This results in a valid comparison of the two-signal distribution techniques.

Test results

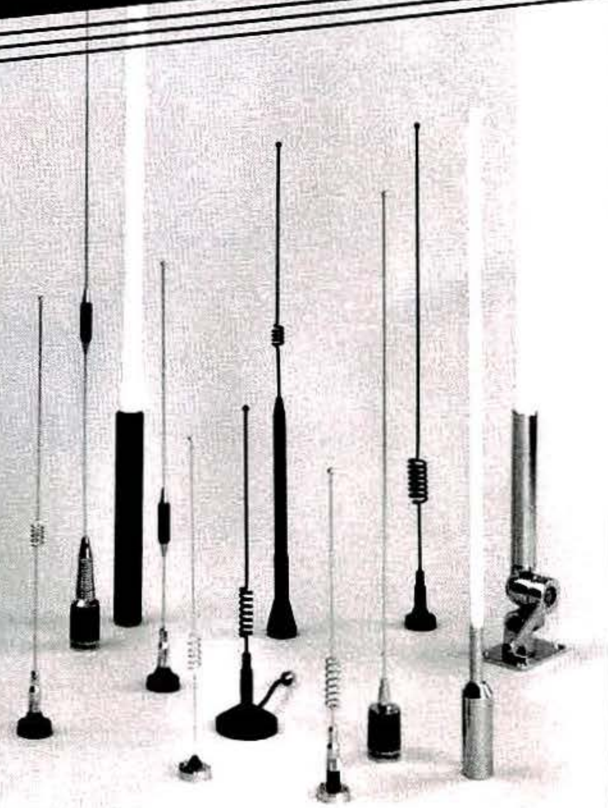
A plot of the path loss values is presented in Figure 3 on page 42. This plot shows the advantage in coverage that is provided by radiating cables.

Notice that the lowest path loss value is provided by the point sources, and that the curve for the radiating cable is flatter. This is how radiating cable can be used to broadcast lower power levels over larger areas.

If the covered area were smaller, the RF distribution would be more conveniently covered by a point-source antenna such as a monopole.

In fact, if all of the available power were distributed through the two monopoles, there would be an additional 10dB at each of the monopoles that would reduce the path loss by the same value. The radiating cable system proved to have an average 5.3dB path loss value advantage over the competing system.

In the 900MHz system demon-



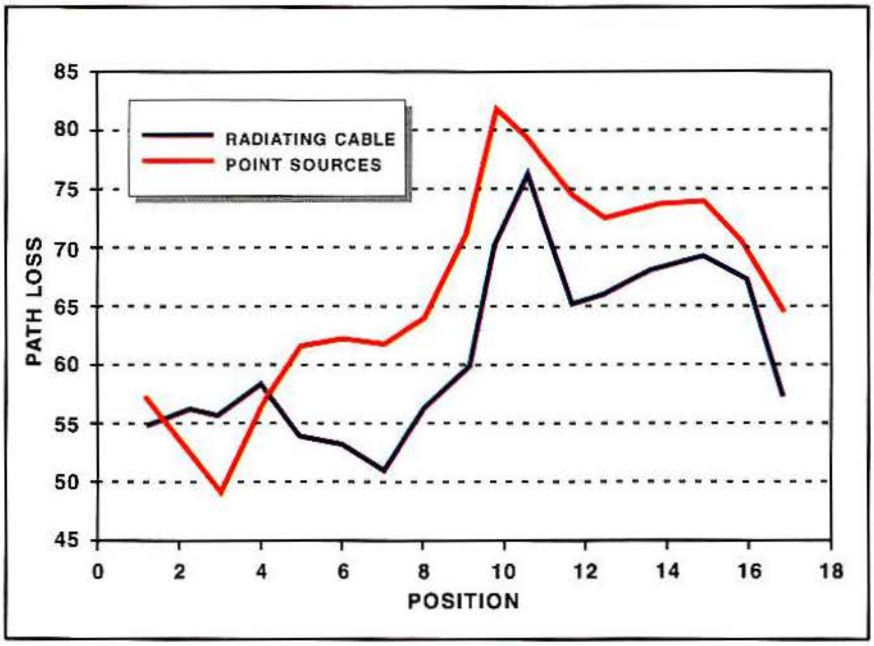


Figure 3. A plot of path loss values shows the advantage in coverage that is provided by radiating cables. The lowest path loss value is provided by the point sources, and the curve for the radiating cable is flatter. This is how radiating cable can be used to broadcast lower power levels over larger areas. If the covered area were smaller, the RF distribution would be more conveniently covered by a point-source antenna such as a monopole.

strated, radiating cable provided better RF coverage using path loss evaluation.

For 14 of 17 locations in the factory, a higher signal level was measured with the radiating cable. In larger systems, radiating cable would have an even greater advantage.

This point is further emphasized by the available power at the output of each system. The available power for an additional area was 16.8dBm for the radiating cable and 10.6dBm for the point-source system (both systems being supplied the same 30dBm input power).

The ease of installation, cost savings in material and labor, and improved RF coverage make radiating cable the clear choice for indoor RF communications transmission.

How F-TDMA can improve private land mobile radio

Frequency-and-time-division multiple-access offers a path that allows refarming of existing spectrum below 470MHz to 12.5kHz spacing by on-center channel migration while delivering a 100% increase in efficiency.

By John Yoon and Barbara Baffer

The digital revolution surrounds us.

Compact discs have overtaken audio cassettes and made vinyl records candidates for antique shops. Television manufacturers have invested six years, since 1987, testing alternative architectures.

Ten years ago, the early personal computers were gaining acceptance. Now, multimedia personal computers integrate video, text and sound for learning and research as well as games.

Digital cellular telephone systems operate in Europe, Japan, the United States and Canada.

Land mobile radio is on the verge of exploiting this same digital technology to deliver increased capacity, improved performance and enhanced functionality. A sound foundation is needed before one can build a good quality house. The same is true for fun-

Yoon is manager of public safety marketing, and Baffer is a regulatory analyst at Ericsson GE Mobile Communications, Lynchburg, VA.

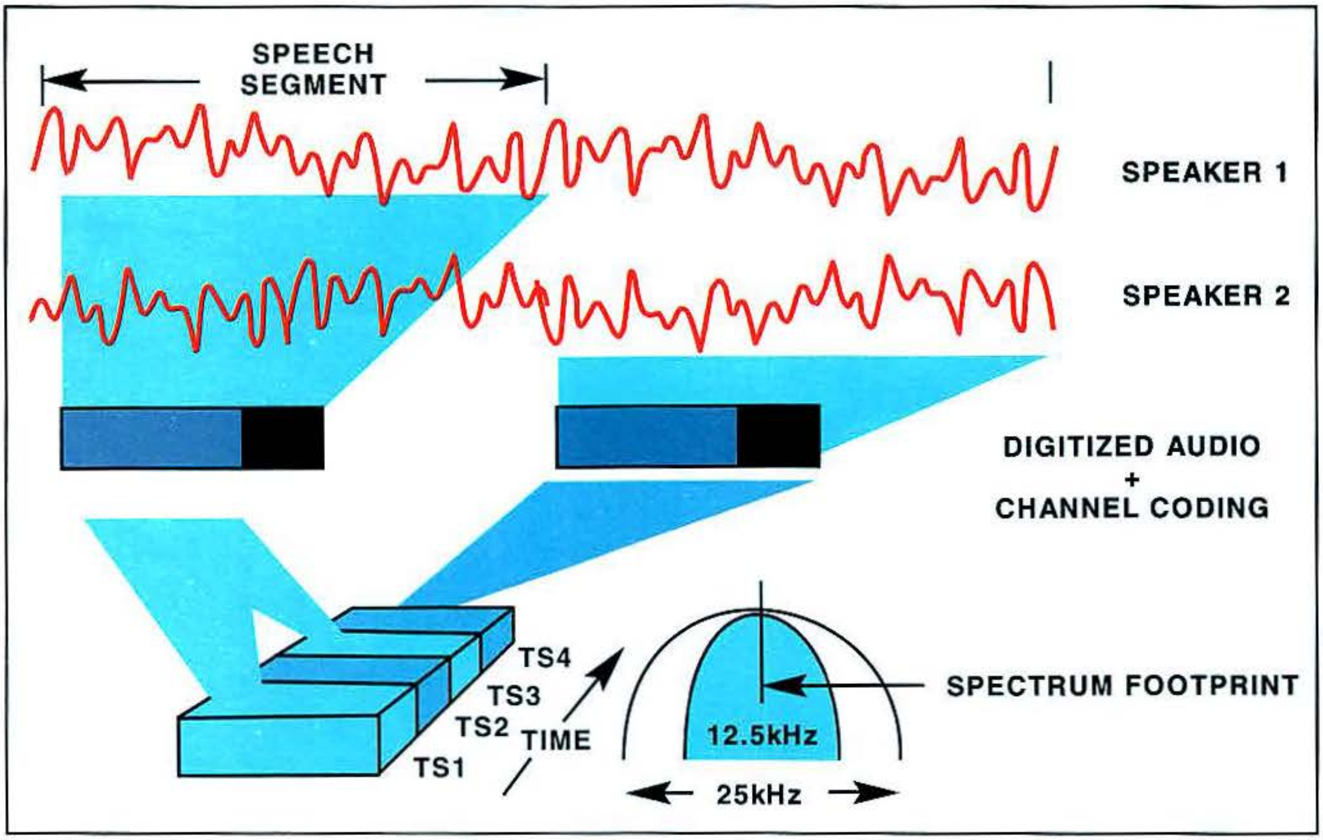


Figure 1. Time-division multiple-access (TDMA) technology allows communications among multiple users by allocating unique time slots to different users. This technique increases capacity by time-multiplexing users on the same RF channel. The shadings represent two distinct user groups. TDMA leaves the channel intact and uses a time reference to keep the data organized within the channel.

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damental technology decisions necessary to build an advanced communication system. The architecture is critical to the delivery of promised advantages to land mobile users.

For example, in the mid '80s, the Japanese rushed to adopt a high-definition television (HDTV) protocol. They selected an analog standard because of the speed of product development. They were the first to offer improved video images.

Unfortunately, no other country has adopted that standard, so the Japanese have been unable to capitalize on being first. Other countries, such as the United States, elected to invest in a digital standard that provides not only improved video and sound, but opportunities for television monitors to serve as the interface to interactive services and to advanced home energy control devices, for example.

Meanwhile, the Japanese will have to trade out their broadcasting and receiver equipment again to enjoy these benefits.

This article explains the radio communications benefits promised with digital technology. Time-division multiple-access (TDMA) technology, a spectrum-efficient implementation for digital land mobile radio, is explained. The characteristics of TDMA are contrasted with another approach, frequency-division multiple-access (FDMA). A proposal for TDMA on narrowband, 12.5kHz channels, termed F-TDMA, is described along with its associated advantages.

Digital technology improves voice and data communications performance . . .

Digital advantages

Digital technology offers increased spectrum efficiencies and advanced features.

Specifically, digital technology offers the following:

▶ *Improved performance*—Digital technology improves voice and data communications performance, thanks to sophisticated digital signal processing (DSP) units in mobile and portable equipment.

▶ *Security*—Digitized speech provides inherent protection and a significant level of privacy and security from conventional scanners.

Sophisticated encryption technology can enhance this security for sensitive tactical communications.

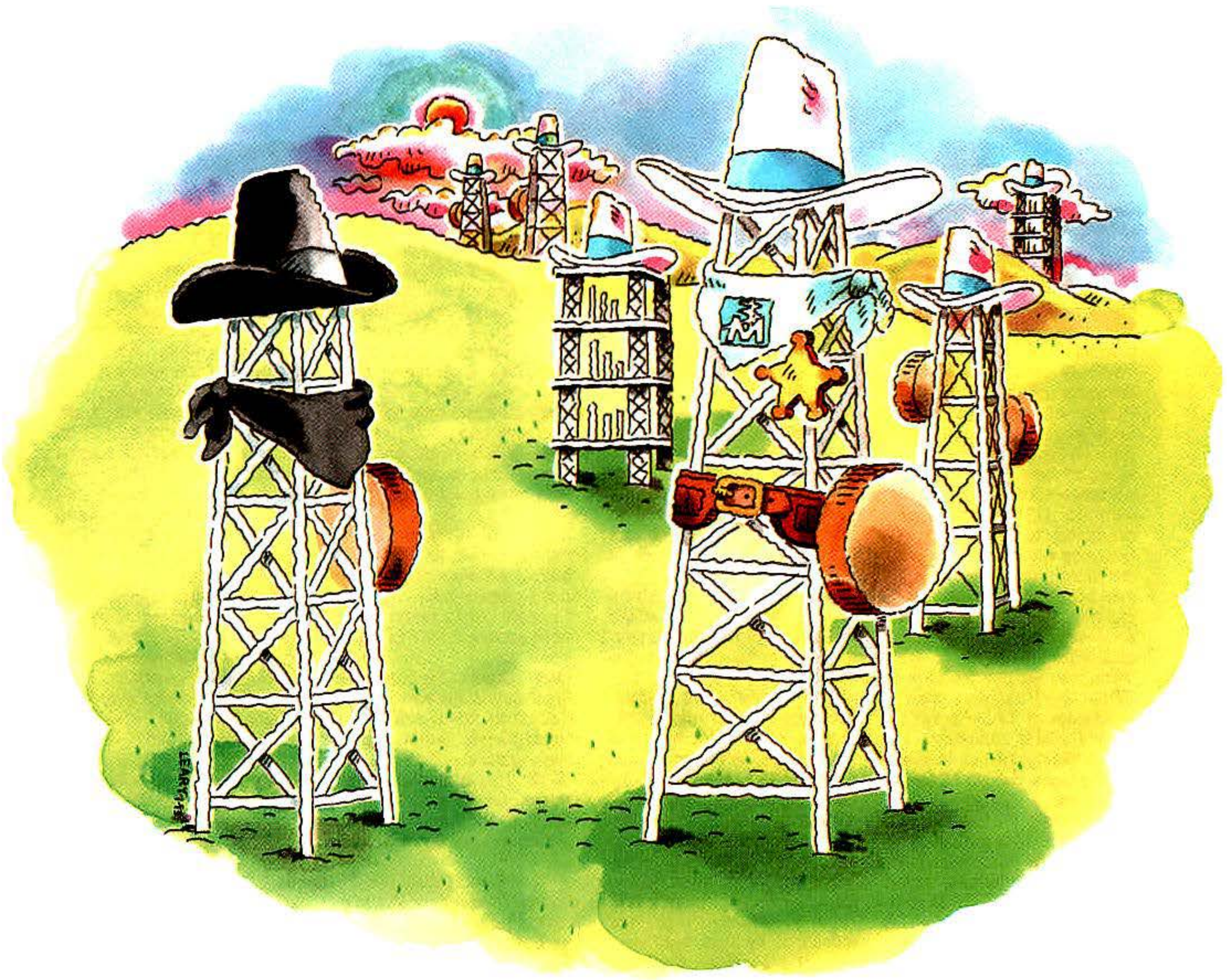
▶ *Advanced features*—Digital technology allows the design of a signaling structure with the flexibility to handle several new features, such as:

□ data-over-voice signaling.

□ automatic power control of subscriber units.

□ high-throughput data and dynamic bandwidth applications.

□ advanced networking and net-



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F-TDMA questions and answers

Ericsson-GE responds to some questions about F-TDMA:

MRT: *How is the digital technology developed as F-TDMA for private land mobile radio (PLMR) the same as the digital technology used in cellular mobile telephone systems?*

EGE: By "the same digital technology," we mean the digital technology used in all kinds of products.

With respect to using digital cellular telephone technology for PLMR, advancements in very large scale integrated circuit (VLSIC) technology have provided an avenue for digital signal processors (DSPs) to be developed. DSPs can be programmed to modify or add functions within a system without redesigning a custom IC. In this sense, digital technology can provide PLMR communications with new and powerful capabilities.

The way we use the term *F-TDMA*, the *F* defines a channel bandwidth of 12.5kHz vs. the current 25kHz bandwidth. The key in this design lies in adapting the digital cellular TDMA for PLMR use.

Fortunately, the use of digital components allows most of the changes to be accomplished via software; therefore, it makes sense to say that F-TDMA is exploiting the same technology as digital cellular. This does not mean that F-TDMA has the same system architecture as digital cellular, though. Technology should not be confused with system architecture.

Although a 12.5kHz, 2-slot F-TDMA system is not yet in production, a prototype was demonstrated at the Associated Public-Safety Communications Officers (APCO) national conference in August in New Orleans. A similar 12.5kHz, 2-slot F-TDMA concept is being defined for the Trans-European Trunked Radio (TETRA) RES-6 standard.

MRT: *You have listed a number of advantages that digital technology has to offer PLMR, such as improved performance, security, advanced features and spectrum efficiency. Are these advantages specific to F-TDMA, or can they be delivered by other digital architectures?*

EGE: Digital technology advances most, if not all, radio architectures.

MRT: *Will scanner manufacturers eventually make receivers that can be used to listen to digital communications? If so, how can digital PLMR users protect their communications from competitors and criminals?*

EGE: It is fairly easy to monitor analog FM communications with a scanner. Digital communications cannot be monitored with the same type of scanner.

Digital scanners, if they ever become available, are likely to carry much higher prices because of the more complex circuitry required compared to analog scanners and because of the required economies of scale.

First, casual listeners and scanner hobbyists who make no use of information in conversations they overhear pose no threat.

Second, the average competitor or criminal who eavesdrops only when it is easy and inexpensive, as with an analog scanner, will not be able to listen to digital communications.

Third, if digital scanners become available, digital radio communications technology offers a low-cost software feature for a low level of privacy and security sufficient to prevent monitoring by stock scanners.

Fourth, sensitive business communications that might be the target of industrial espionage and tactical public safety communications that might be the target of sophisticated criminals can be protected with digital encryption standard (DES) encryption.

DES encryption requires such enormous resources and so much time to decode without first knowing the key that the information it protects usually is without value by the time it is decoded.

MRT: *One of the advantages of digital communications you describe is dynamic bandwidth. Does that mean that the bandwidth changes from time to time?*

EGE: Yes, although the bandwidth would not change during a single call.

Dynamic bandwidth might be referred to as *bandwidth on demand*. In an F-TDMA system, the bandwidth never would be greater than what current regulations specify.

Here are two examples of how dynamic bandwidth applies to an F-TDMA system:

(1) An F-TDMA system with dynamic bandwidth equipment offers a migration path from the current "maximum" bandwidth (25kHz) to a "one-half maximum" bandwidth (12.5kHz).

Imagine a single base station that can talk to old (maximum bandwidth) and new (one-half maximum bandwidth) radios. With such a base station, existing radio units do not have to be replaced simultaneously with new units.

(2) Using F-TDMA on a 25kHz channel allows four users to conduct separate communications simultaneously. This type of system configuration is permitted under current FCC rules.

MRT: *Doesn't the promise of digital technology transfer lie in its ability to deliver a high information transfer rate without increasing bandwidth?*

EGE: This is correct; nevertheless, some data applications such as transmitting fingerprint images require a wider bandwidth.

F-TDMA can satisfy requirements for wider bandwidths by providing the flexibility to combine bandwidths of multiple time slots. As technology evolves, the amount of bandwidth required will decrease. Digital technology will promote this bandwidth reduction further, along with the ability to deliver a higher information transfer rate.

Despite the current need for wider bandwidths for specific applications, digital technology not only provides higher information throughputs, but also uses vocoder algorithms to compress voice (which is spectrally inefficient) into a smaller bandwidth.

MRT: *Why aren't high channel data rates possible, such as 16kb/s in a 12.5kHz channel? Why can't a 12.5kHz FDMA channel also operate at a 16kb/s data rate?*

EGE: Data rates are a function of modulation techniques and occupied bandwidth (mask of signal).

The 16kb/s data rate fits within the current FCC Part 88 mask using a 4-phase modulation scheme. A 4-phase modulation scheme ($\pi/4$ DQPSK) is used because this demodulation technique can be implemented easily using today's DSP technology.

More complex modulation schemes, such as 8 QAM and 16 QAM, typically require linear amplifiers to maintain energy within the mask and signal characteristics. Linear amplifier technology is advancing at a rate that should allow these more complex modulation schemes to be applied to digital PLMR in two years or so. Where 4-phase modulation can achieve a 16kb/s data rate, 16 QAM (phase) modulation can increase the rate to approximately 32kb/s.

Another way to improve channel capacity without increasing bits/sec/Hz is by further compressing voice signals into a vocoder. Current vocoder technology compresses voice approximately 4kb/s, but it requires approximately 3kb/s of error correction.

Although this represents significant progress from where technology was a few years ago, improvements in vocoder technology are forthcoming. Higher data rates are possible, but modulation scheme selection is limited by linear amplifier technology and demodulation DSP complexity.

MRT: *Isn't the real issue information transfer rates vs. bandwidth with frequency reuse? Information about adjacent channel protection ratios and co-channel reuse or desired-to-undesired signal ratios would be useful.*

EGE: Yes, frequency reuse is a factor in estimating spectral efficiency.

Our F-TDMA approach uses the same frequency reuse plan that exists today. No new frequency coordination plans are required.

F-TDMA produces 100% spectral efficiency improvement over 12.5kHz FDMA systems and a four times improvement over 25kHz analog systems. The unique feature of F-TDMA is its allowance for transparent migration on existing frequencies without performing a new frequency coordination plan.

Think of it as a mobile "workstation" that delivers everything on the menu.

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work-wide features.

▶ *Spectrum efficiency*—Digital technology, when implemented properly, promises increased spectrum efficiency, i.e., the ability for higher numbers of users to share the same spectrum (higher capacity) or the ability to pass higher quantities of data (higher *throughput*) through a radio system. With available technology, capacity gains of 100% within 12.5kHz channels and at least 300%-440% in 25kHz channels are possible. Data rates exceeding 30kb/s in 25kHz channels or 16kb/s in 12.5kHz channels are possible.

Spectrum congestion is a fact of daily life to many land mobile radio users. The FCC has initiated a *Notice of Proposed Rulemaking* in PR Docket No. 92-235 to *refarm* frequencies below 512MHz to make additional capacity available. Although it is not required by the refarming initiative, digital technology provides a way to gain spectrum efficiency while improving service quality and functionality. The alternative of new, *green* spectrum is not available to meet the demand for private land mobile radio services.

Competing technologies

TDMA is a relatively new entrant into mobile communications and is challenging traditional approaches.

TDMA historically has been projected for 25kHz or 30kHz land mobile channels. A number of countries, including the United States, have adopted or plan to implement 12.5kHz channels in some frequency bands. This has led our company to develop TDMA for operation on narrowband, 12.5kHz channels, termed F-TDMA.

For cellular telephones, TDMA systems are available and operating successfully in many of the large North American markets. Several of the largest specialized mobile radio (SMR) system operators have announced that they will install TDMA technology to gain interoperability and to facilitate wide-area roaming.

The authors' company has supported TDMA for private radio since 1989, when the access technology for private radio first came to be publicly debated in the FCC's *Further Notice of Inquiry* in Gen. Docket No. 88-441.

TDMA uses a common channel for communications among multiple users by allocating unique time slots to different users. This technique increases capacity by *time multiplexing* users on the same RF channel.

The shadings in Figure 1 on page 44 represent two distinct user groups. Each group uses the channel resources on a time-shared basis.

In effect, TDMA leaves the channel intact and uses a time reference to keep the data organized within the channel. The users are not aware that they are sharing an RF channel. Cellular telephone, landline telephone, digital microwave and other electronic switches use a similar technique to multiplex conversations.

Frequency-division multiple-access (FDMA) narrows the channels from 25kHz or 30kHz to 12.5kHz. In some cases, adjacent channel interference prevents simply splitting a 25kHz channel into two 12.5kHz channels.

"Multiple access" is a misnomer in the case of FDMA. In fact, unless the user is licensed to adjacent channels, only one user can occupy the channel at a time.

Incorporating the advantages of narrowband channels with the capacity and flexibility of TDMA, F-TDMA provides two-slot TDMA on 12.5kHz channels, as shown in Figure 2 to the left. Capacity is absolutely doubled on each narrowband channel.

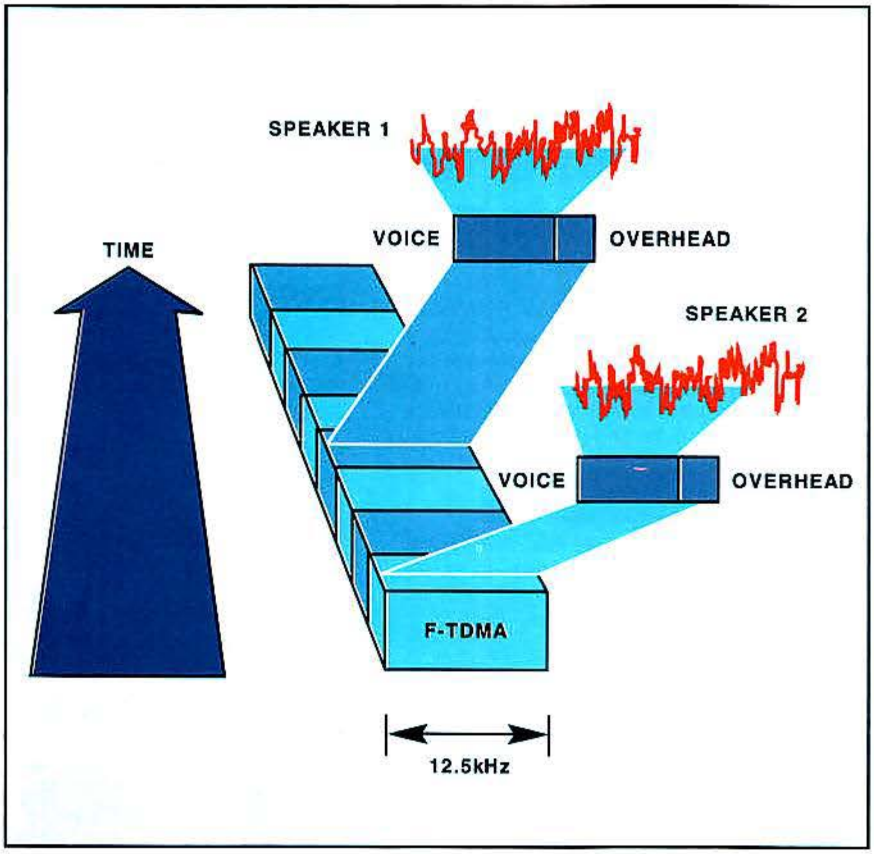

Figure 2. Incorporating the advantages of narrowband channels with the capacity and flexibility of TDMA, F-TDMA provides two-slot TDMA on 12.5kHz channels. Capacity is doubled on each narrowband channel.

Digital modulation

In digital technologies, information is transferred through the air using electromagnetic energy, and the properties of these waves are determined by a modulation scheme.

Modulation techniques often determine the gross bits per hertz. One way digital technologies increase spectrum efficiency is through the modulation scheme. A linear modulation scheme, *differential quadrature phase-shift keying* (DQPSK) is a good match for some

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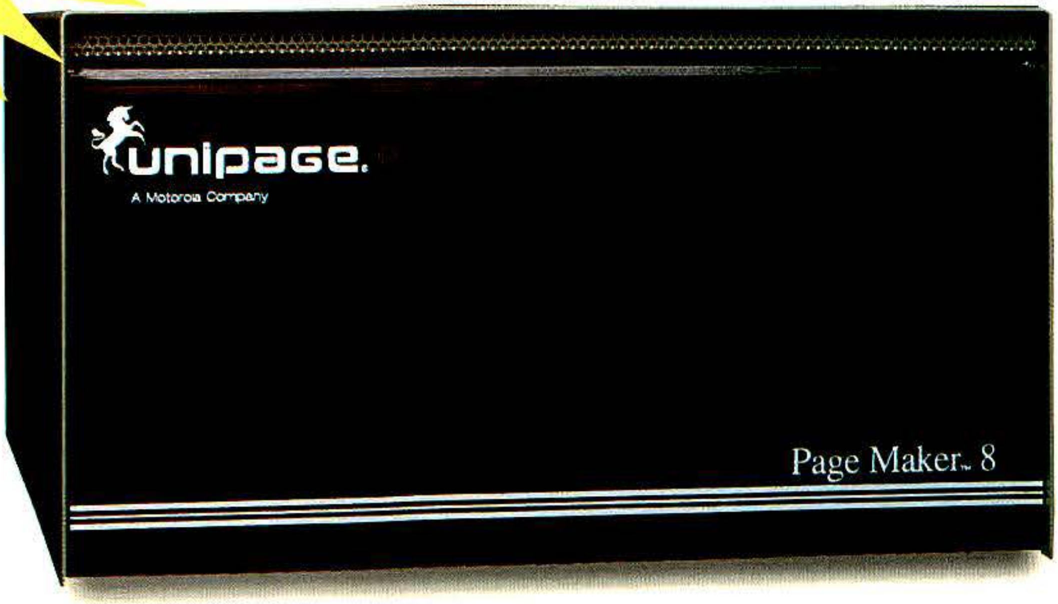

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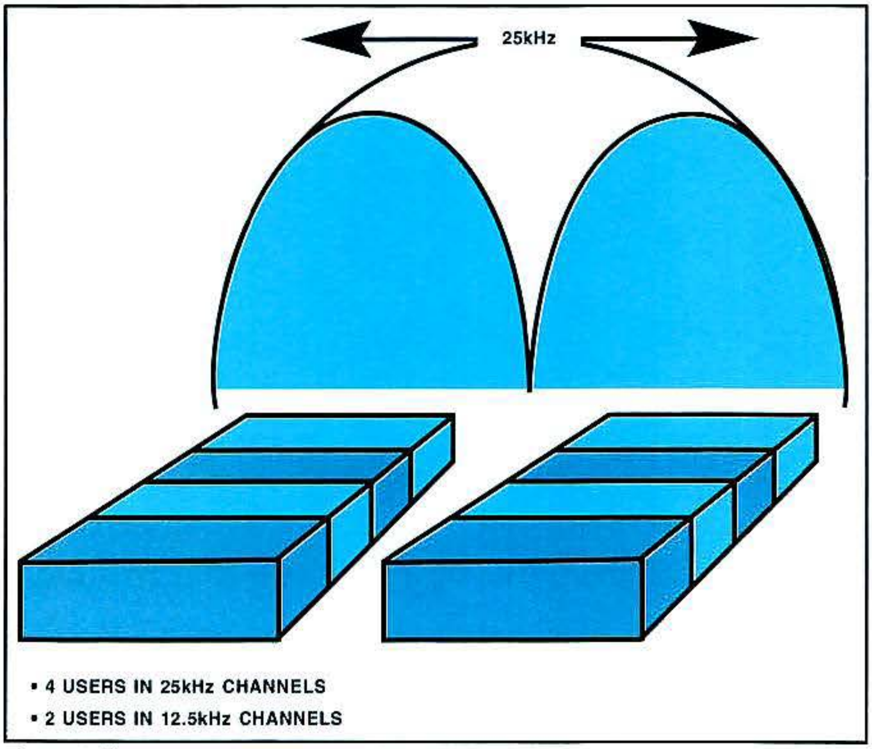

Figure 3. The refarmed spectrum allows two TDMA carriers 12.5kHz apart on a 25kHz channel. This method allows four users on the equivalent of one current channel.

TDMA applications.

DQPSK-modulated F-TDMA can be used in the downlink and can accommodate 16kb/s in a 12.5kHz channel. DQPSK modulation is selected for the downlink communications path to allow simulcast to be implemented. DQPSK represents digital data by shifting the relative phase of the carrier to represent digital symbols. The uplink path, mobile-to-base, will be supported by *continuous phase partial response modulation* (CPM) that eliminates the need for linear or quasi-linear amplifiers in hand-held equipment.

Vocoders

Voice coders (vocoders) are used in digital systems to convert analog speech into digital signals for transmission.

At the receiving end, the vocoder translates the digital signal back into analog speech.

To increase the information transmission efficiency for digital private

land mobile radio systems, the vocoder's data rate must be decreased. This rate reduction is accomplished within the vocoder, which removes redundancy in the speech signal waveform.

Therefore, the *improved multiband excitation* (IMBE) vocoder, based on its superior test performance and availability, is selected for use in F-TDMA equipment. The IMBE vocoder's data rate allows two users to communicate simultaneously within the channel capacity of 16kb/s in a 12.5kHz channel.

Linear amplifiers and TDMA

Continuous phase modulation (CPM) is used in the uplink. This method offers a particular benefit in digitally modulating mobiles and portables because non-linear amplifiers still cost less than linear amplifiers. The cost advantage, along with the higher efficiencies of non-linear amplifiers, makes CPM a logical choice for portable F-TDMA radios.

Using DQPSK on the downlink requires a linear or linearized amplifier; still, modulation is used only for base stations where this technology is widely available. DQPSK is a good modulation choice for the downlink because any receiver capable of modulating and demodulating DQPSK is capable of decoding other modulation schemes.

By narrowing the bandwidth and applying F-TDMA technology, multiple spectrum savings are achieved.

Talk around or simplex

Because F-TDMA is compatible with 12.5kHz operation, talk around is also possible.

Any F-TDMA radio can operate in the talk-around mode by operating in an FDMA mode, using QPSK modulation and 12.5kHz digital talk around. QPSK is a 4-phase modulation technique in the same family as CPM. Channel efficiency is not compromised when the radio operates in the talk-around mode.

F-TDMA on existing channels

By narrowing the bandwidth and applying F-TDMA technology, multiple spectrum savings are achieved.

The F-TDMA technology provides the equivalent of 12.5kHz channelization on existing 25kHz allocations (e.g., 806MHz-821MHz or 450MHz-470MHz), a twofold increase in current National Public Safety Planning Advisory Committee (NPSPAC) channel allocations (821MHz-824MHz), and a migration path to the proposed 12.5kHz channels below 512MHz.

(continued on page 80)

The New Standard in Radio Communications Test Equipment

The FM/AM-1600S combines a large color CRT and multiprocessor control to provide maximum performance and ease of use.

The color CRT displays all information necessary to test an RF transmitter or receiver. Keystrokes are kept to a minimum by the extensive use of "soft keys". The user can even select the colors to be displayed from a 16 color palette. The result is a level of operator convenience never before encountered in a service monitor.

The RF system of the new FM/AM-1600S provides excellent spectral purity along with FM, AM and ΦM capabilities. The instrument's independent RF Generator and Receiver allow frequency offsets to 1 GHz for applications such as cross-band repeater tests and RF injection while signal tracing a receiver front-end and I.F.

The digitized Spectrum Analyzer provides scan widths from 1 kHz/div to full scan, plus store, recall, compare and peak hold trace modes. Log scales of 10 or 2 dB/div and amplitude units scaled in dBm, dBμV, dBmV, dBV or dBμW.

Additional unique features include Tracking Generator; digitized 1 MHz Oscilloscope; 2 AF Function Generators; Bit Error Rate (BER) Meter and multiprotocol Data Communications Generator; Power Meter with extended dynamic range of 0.2 mW to 200W; "store" and "recall" of front panel setups; RS-232C, IEEE 488.2-1987, SCSI (ANSI X3.131-1986) and EGA interfaces.

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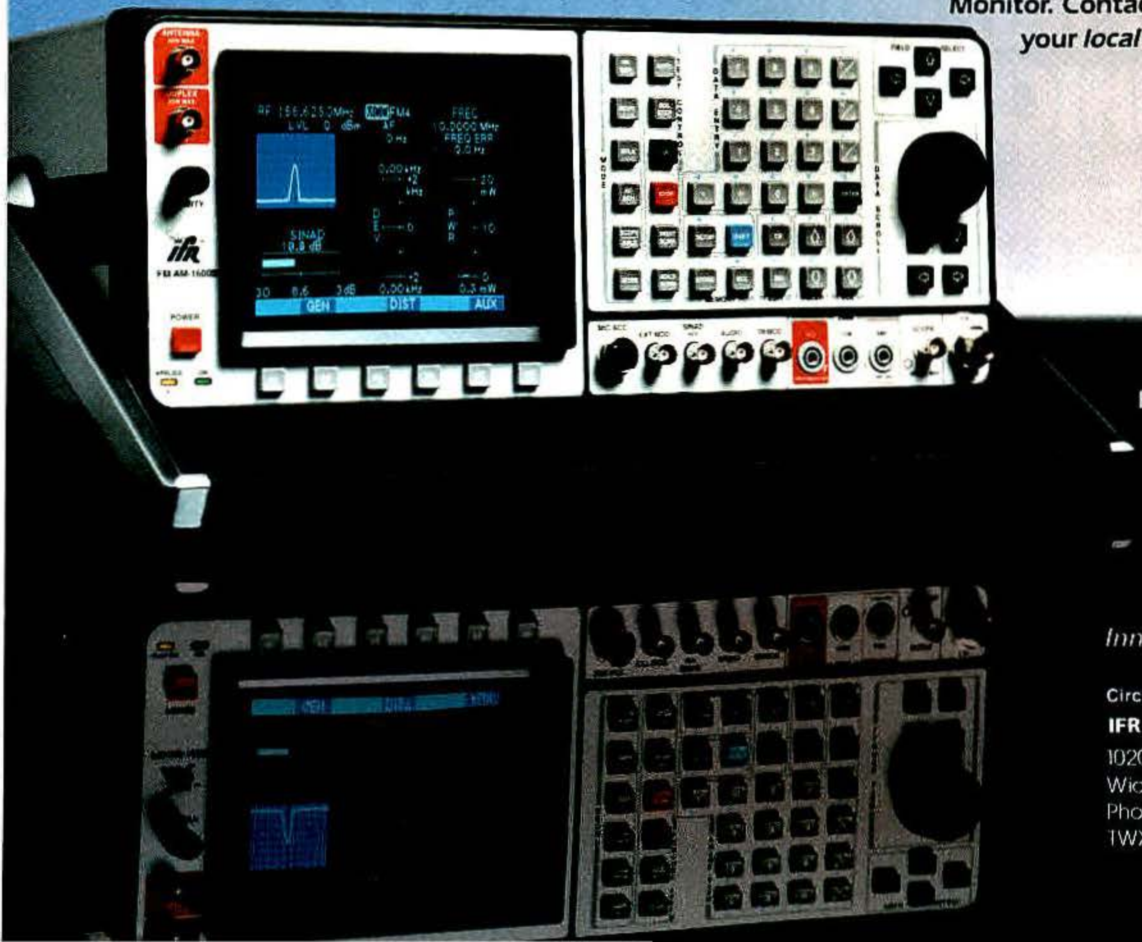

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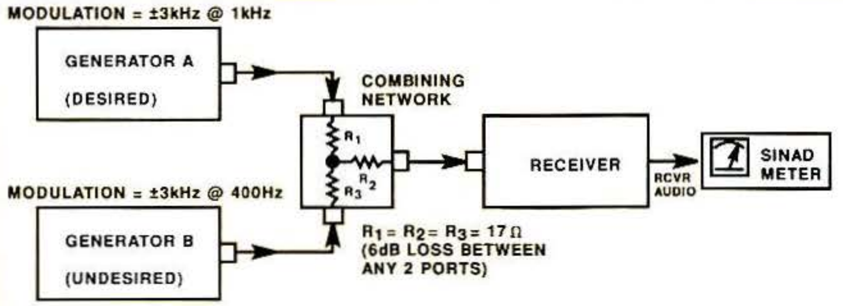

1) Connect equipment as shown above. With signal generator B (undesired) off, adjust generator A (desired) modulation to ±3kHz with a 1kHz tone. Adjust the output level of generator A to produce 12dB SINAD at the output. Record the level of generator A in dBm. This is the *reference* sensitivity of the receiver.

2) Increase the level of generator A by 3dB.

3) Set the frequency of generator B to the frequency that you are interested in checking. For example, if you are interested in knowing what the desense characteristic is at +225kHz, then set generator B to that frequency.

4) Increase the output level of generator B until the SINAD meter drops back to 12dB SINAD. Record the output level of generator B in dBm.

5) The difference in the recorded generator levels in steps 1 and 4 is the *desense immunity* of the receiver at this particular frequency.

Note: This procedure is based on established EIA method found in publication TIA-EIA-603. Call 1-800-854-7179 for ordering information.

Figure 2. To determine how much isolation is needed to prevent receiver desense, it first is necessary to know the specific receiver desensitization characteristic. If you do not have the manufacturer's data sheet, you can perform the standard EIA or TIA test for *adjacent channel selectivity and desensitization.*

(continued from page 8)

For extra insurance, the signal should be suppressed another 10dB, to −36dBm, at the receiver input.

Suppose the transmitter output power is 100W or +50dBm. This means that an isolation of 50dBm −

For extra insurance, the signal should be suppressed another 10dB, to −36dBm, at the receiver input.

−36dBm = 50 + 36 = 86dB must be provided between the transmitter output and the receiver input to minimize receiver desense caused by the nearby transmitter. (Figure 3 on page 58 shows antenna isolation figures for horizontal or vertical antenna separation.)

For a summary of the isolation pro-

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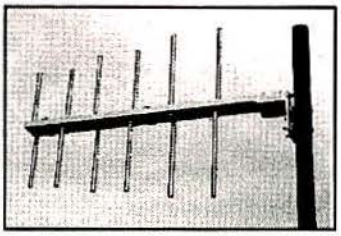

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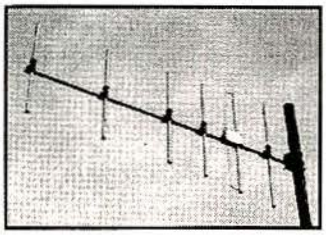

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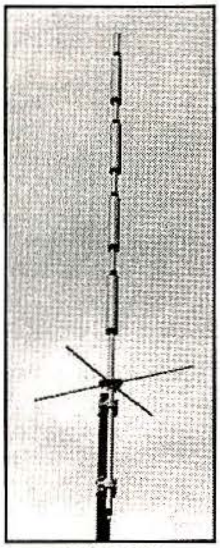

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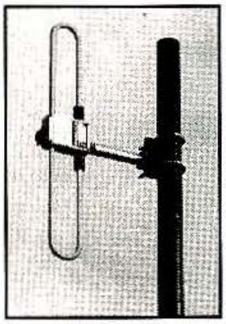

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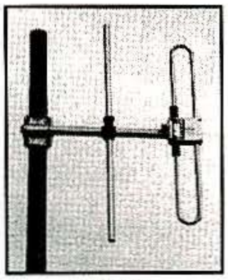
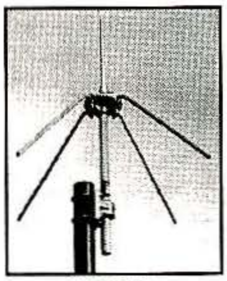


CA2-220



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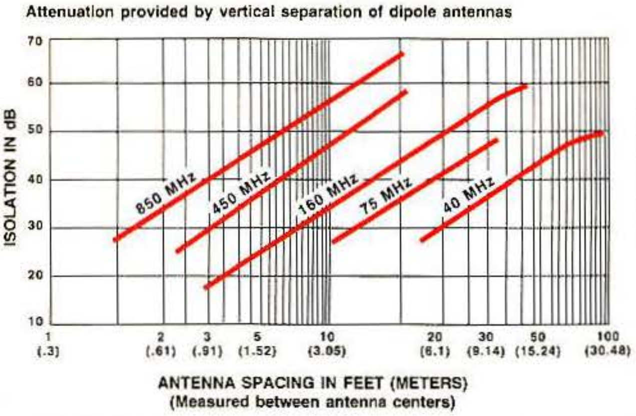
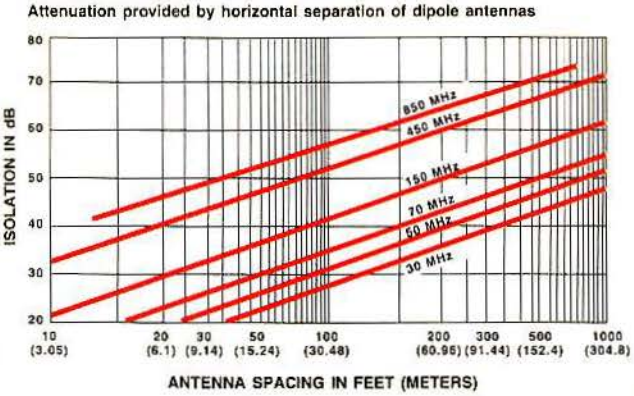


The values indicated by these curves are approximate values because of coupling which exists between the antenna and tower transmission line. Curves are based on the use of half-wave dipole antennas. The curves will also provide acceptable results for gain type antennas if (1) the spacing is measured between the physical center of the antennas and if (2) one antenna is mounted directly above the other, with no horizontal offset (exactly collinear). No correction factor is required for the antenna gains.



Curves are based on the use of half-wave dipole antennas. The curves will also provide acceptable results for gain type antennas if (1) the indicated isolation is reduced by the sum of the antenna gains and if (2) the spacing between the gain antennas is at least 50 ft. (15.24 m) (approximately the far field).

Figure 3. These graphs indicate the amount of isolation provided by (A) vertical spacing and (B) horizontal spacing of antennas. (Courtesy of Decibel Products, Inc.)

vided in Figure 1, refer to Figure 4 on page 60. Based on Figure 4, after all the isolation figures are taken into account, the net signal level at the receiver input is +8dBm.

Remember, to avoid causing receiver desense, the signal must be suppressed to a level no greater than −36dBm at the receiver input; thus, an additional isolation or attenuation of +8dBm − −36dBm = 44dB is needed. This isolation can be accom-

plished by using a low-pass notch filter at the receiver input.

The graph in Figure 5 below represents the amount of isolation versus frequency required by two different receivers (A and B).

These amounts represent the isolation provided by actual equipment from large manufacturing companies. If receiver A is used on a site where a transmitter is transmitting at a frequency 1MHz removed from the receiver frequency, the graph indicates that an isolation of 40dB is needed to prevent receiver desense.

If receiver B is used in the same situation, an isolation of 61dB is required. Which receiver is the better choice for use on this site? Receiver A is, because it requires 21dB less isolation than

Transmitter level	+50dBm
Transmitter line loss	−02dB
Antenna isolation	−38dB
Receiver line loss	−02dB
Net signal level at receiver	+08dBm

Figure 4. This summary of the isolation provided in Figure 1 shows that after all the isolation figures are taken into account, the net signal level at the receiver input is +8dBm.

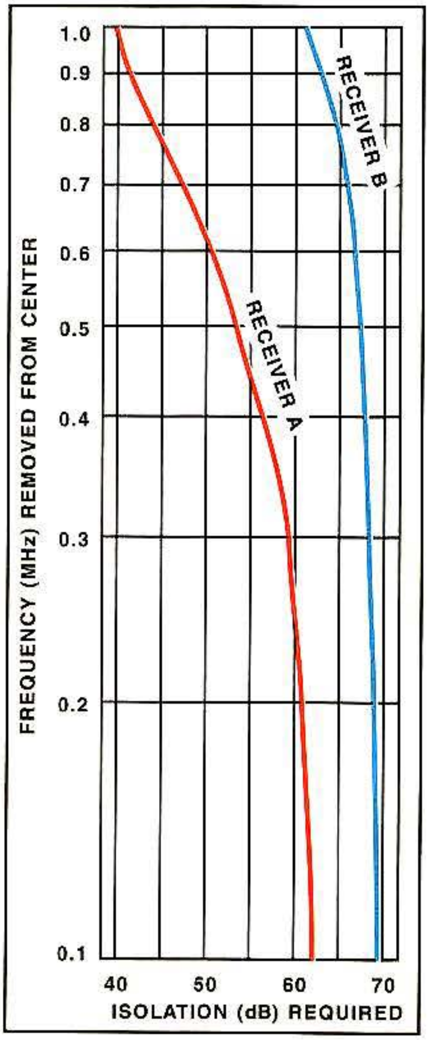


Figure 5. These graphs show the amount of isolation required between a transmitter operating at 100W (+50dBm) and each receiver (A and B) with a sensitivity of 0.35μV or −116dBM at 12dB SINAD. Note that receiver A requires less isolation than receiver B. Thus, receiver A is a better choice for use at a site where many transmitters might be operating at a frequency near that of the receiver. At 1MHz, receiver B requires 21dB more isolation than receiver A.

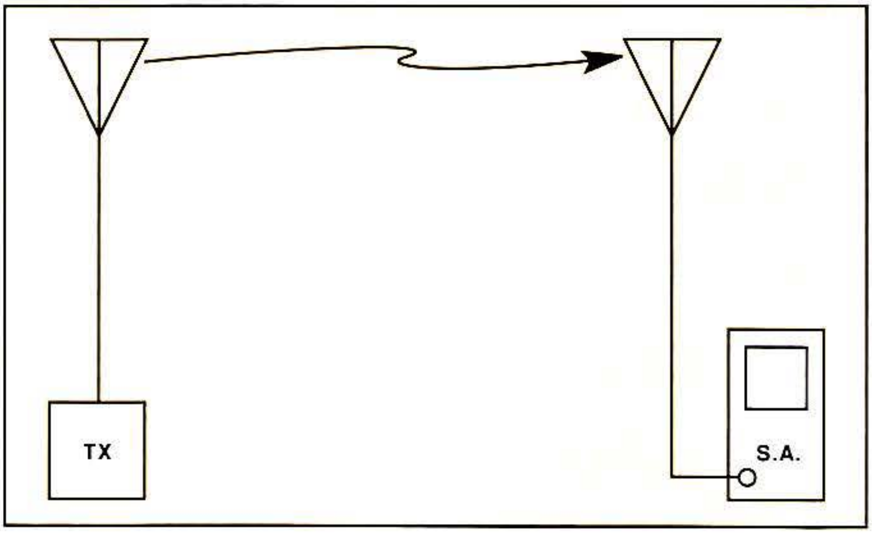


Figure 6. This direct measurement method can be used to determine the actual isolation between a transmitter output and a nearby receiver input. Simply connect the spectrum analyzer input to the cable normally connected to the receiver input. Be sure not to bypass any filters in making this measurement. With the transmitter keyed, the signal level is measured directly on the spectrum analyzer in dBm. Then, the measured signal level in dBm is subtracted from the transmitter output level in dBm to get the isolation in dB between the transmitter output and receiver input. This method provides a more accurate means of determining how much *additional* isolation is needed to prevent or to minimize receiver desense.

receiver B.

This choice can save considerable money on expensive filters. Maybe one "can" will do instead of two, or it may be possible to achieve sufficient isolation by simply changing the antenna spacing.

Direct measurement of isolation

Although graphs such as those shown in Figure 2 are helpful in determining the *approximate* isolation provided by horizontal or vertical antenna separation, a more accurate determination can be made by the *direct* measurement method if the antennas *already* are in place. (See Figure 6 above.)

The transmitter is transmitting on 151.325MHz. It is located in the immediate vicinity (same site) of a receiver tuned to 151.100MHz. With the transmitter keyed, the signal level at 151.325MHz is measured at −30dBm on the spectrum analyzer, which is connected to the antenna that normally would be connected to the receiver input.

Assuming a 100W (+50dBm) transmitter power, the isolation between the transmitter output and the receiver input is +50 − −30 = +50 + 30 = 80dB.

To summarize, the amount of isolation required to prevent receiver desense depends upon the receiver design and the transmitter output power. Any filtering must be installed on the receiver side and must be tuned to the transmit frequency.

Filters are expensive and cause some insertion loss at the desired frequency; therefore, it is more desirable to use a higher-quality receiver and less filtering to achieve superior performance. Always closely examine receiver desense characteristics before buying! This advice is especially important when a receiver is intended for use at a high-density site.

Always closely examine receiver desense characteristics before buying!

News

AlliedSignal sells mobile radio line to Adage

AlliedSignal has signed an agreement to sell its Bendix/King line of mobile radios to Adage, West Chester, PA. The sale is expected to be effective by mid-September. Adage plans to move production of the Bendix/King land mobile product line to its Relm Communications production facility in Melbourne, FL. After completion of the acquisition, Adage's annual sales in the wireless communications business are projected to exceed $50 million.

Strategic Telecommunications offers worldwide technical services

Strategic Telecommunications, Dallas, began operations on July 30 to offer worldwide technical services such as project engineering and management, consulting, systems engineering, and installation and testing of telecommunications.

Company president Robert C. Shapiro, P.E., created the company along with three partners. Shapiro previously was a contract consultant with RAM Communications Consultants in Dallas and a systems engineer with Alliance Telecommunications-Decibel Products in Dallas.

Vice president of network engineering James Schell is working on a contract in Europe commissioning DMS switches. Marketing vice president Kevin Henry is installing a cellular system in western Africa. Tim Tilton, vice president of MidEast Operations, is currently installing a microwave system in the Middle East.

Strategic Telecommunications is at 14832 Venture Drive, Dallas, TX 75234; phone 214-484-9963; fax 214-241-2583.

CenCall Communications goes public

CenCall Communications, Denver, announced an initial public offering of 4,750,000 shares of its common stock at $19 per share. According to CenCall, the company is the third largest specialized mobile radio (SMR) system operator in the United States. The operating regions cover parts of Colorado, Kansas, Missouri, Oklahoma, Washington, Oregon, Idaho, Wyoming and Texas with a population of about 19 million.

The net proceeds of the approximately $82.7 million will be used to repay existing debts, to partially fund the build-out of high capacity digital mobile networks and possibly to fund future acquisitions.

CenCall digital mobile network service is expected to be available in Denver and the Colorado front range, Seattle and Portland by early second quarter 1994; in Kansas City, Oklahoma City, Tulsa and Wichita during the first quarter of 1995; and throughout the rest of CenCall's operating regions by the end of 1996.

PacTel Teletrac expands distribution channels

PacTel Teletrac, Inglewood, CA, is expanding its indirect distribution channels to include dealers and value-added resellers specializing in the delivery of mobile communications and security products and services. Qualified companies will be able to add Teletrac Fleet Director to their existing services.

The company will offer authorized dealers the Fleet Director work station and in-vehicle hardware at wholesale prices, in addition to revenue sharing on airtime usage generated by subscribers whom dealers have activated on the Fleet Director system. Value-added resellers will be able to purchase Fleet Director software, hardware and network airtime from PacTel Teletrac and then offer the comprehensive vehicle location and security services directly to their customers under their own company name and packaged with their own services.

LeBlanc opens regional offices

LeBlanc Communications, Sacramento, CA, has opened regional offices in Lewisberry, PA, that will house both a regional headquarters and a service branch for LeBlanc's tower and technical services divisions. The address is 571 Industrial Dr., Lewisberry, PA 17339; phone 717-932-4440; fax 717-932-4425.

Overland Park, KS, buys EDACS

The Overland Park, KS, city council approved the acquisition of an 800MHz radio trunking Enhanced Digital Access Communications System (EDACS) from Ericsson GE, Lynchburg, VA. Phase one of the project is for a 5-channel simulcast EDACS with encryption to be used by the Overland Park Police Department.

The battleground at 900MHz

By Robert H. Schwaninger Jr.

Back in the 1950s, the spectrum battle was in the 150MHz band.

In the '60s and '70s, operators fought for control of the 450MHz band, taking no prisoners. With the advent of cellular mobile telephone and specialized mobile radio (SMR) operations throughout the '80s, the popular place to pick a fight was in the 800MHz band.

Welcome to the '90s, where the turf wars are being waged in the 900MHz band.

As always, the stakes are high. Millions of dollars will be won or lost before the dust clears. Small entrepreneurs with tenacious, courageous spirits will become wealthy. Large companies will set the tone and rock the industry in the name of self-interest. New devices and services employing the band will come to the fore. And meanwhile, the FCC will continue its efforts to balance and rebalance the interests.

Comments received in the FCC's rulemaking proceeding for the 902MHz-928MHz band (PR Docket No. 93-61) have fully demonstrated the communications industry's interest in the 900MHz band's future use.

Location monitoring

The proposed rules allocate the bulk of the band to wideband Location Monitoring Service (LMS) systems that would provide position information of vehicles, people, transmoduals, cargo and just about anything else. North American Telecom was advocating that two systems per market, operating on 8MHz-wide channels, be provided exclusive use of the band to deliver the service.

Welcome to the '90s, where the turf wars are being waged in the 900MHz band.

The avalanche of comments received to this proposal came from all corners. Spread-spectrum operators immediately decried the proposed use of the band as deadly to their operations. Spread-spectrum devices have become more commonplace as manufacturers master the art of received gain and pulse technology, and most of these devices operate in the 902MHz-928MHz band.

The requested allocation also would adversely affect manufacturers and operators of local area networks (LANs) that share the band, often using spread-spectrum technology.

Low-power, unlicensed device manufacturers probably were the most vocal in opposition. The proposed use of the band for LMS would place hundreds of transmitters in each served market with an authorized power of 300W ERP. The interference potential to cordless phones, smoke detectors, electronic toll systems, wireless security devices and many other products is sufficiently significant to have caused a collective wail from manufacturers and operators who easily could see their devices' reliable operation eroding within a competitive radio environment.

Radio amateurs

Another large group of offended parties were amateur radio operators. Amateurs use the band to transmit video.

A number of users and proponents stated flatly that the proposed LMS systems would eliminate their use of the band and should be denied by the FCC as an unnecessary use of the radio spectrum. The tenor of the amateur operators' comments was, in part, a reaction to some LMS comments that suggested that amateurs be removed summarily from the frequencies to make pristine room for LMS systems.

The truth is that the FCC does not want to hurt manufacturers of unlicensed radio devices that use the band. The FCC does not really want to bother the amateurs, who just lost their allocation at 220MHz-222MHz not long ago.

The FCC sees promise in spread-spectrum and still wants to promote investment in that technology. The FCC is

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He has a financial interest in the site guide mentioned in this column.

sympathetic to LAN manufacturers and operators, as well.

However this rulemaking ends, somebody is going to get hurt, and somebody is going to pay the price. Conversely, somebody is going to make a bundle.

For an absolutely guaranteed, lead-pipe-sure prediction of how this one will come out, ask your broker. Brokers always claim to be able to predict the future.

Crystal ball

If you want a more humble, qualified opinion from someone armed with little more than some used tea leaves and a cracked crystal ball, here's my best guess. LMS will be created, but on *4MHz-wide systems,* employing *shared spectrum,* coordinated by *NABER.** (NABER asked for the job in its comments.)

Electronic toll systems will migrate to a higher band to avoid the fracas, and the FCC will allocate spectrum to assist them. Amateurs, LANs, spread-spectrum users and unlicensed devices will be provided with approximately 12MHz of spectrum in the band to continue operations and development. Would this satisfy everyone? No, but when does that ever happen?

At the 929MHz band, applications for new PCP systems are pouring into the FCC. The rulemaking that would provide for exclusive use of these paging frequencies has not concluded, but operators are banking on its approval and are applying in record numbers.

However this rulemaking ends, somebody is going to get hurt, and somebody is going to pay the price.

In the olden days (three years ago), putting together a stack of applications to serve the entire United States would have been nearly impossible. Nobody could find enough site information to complete applications for nationwide systems.

With the publication of *Fryer's Site Guide,* all the site information can be had easily, and anxious speculators are using it time and again. Now, instead of applicants having to spend literally months to collect site data to cover a single state, the guide enables system designers to complete in one week enough applications to serve the entire nation.

The result is that existing operators who were dreaming of exclusivity via the rulemaking are seeing forced sharing of their channels in the form of a blizzard of applications from nationwide and regional *wannabes.* Large operators are carving out territory and spectrum turf with bundles of applications that scream "Mine, mine, mine!", and the clock continues to tick as all licensees and applicants await the FCC decision that will set the rules for this ongoing struggle.

Waiting

At 931MHz, applicants are awaiting the publication of the FCC's *Order* rewriting Part 22. Ever since the FCC decided that no one can apply for frequencies that are "covered" by expired, but not purged, construction permits, there has been an enormous tangle of pending applications stuck at the FCC.

Applicants in Southern California have filed a backlog of applications for more than a dozen proposed systems. Meanwhile, applicants and the FCC's Mobile Service Division await changes in the rules before the staff intends to make any grants except for fill-in transmitters. That web is so tangled that the FCC does not even want to talk about it.

The result is that new construction and expansion projects of a number of 931MHz common carrier paging systems have been halted in their tracks. Even logical, conservative growth has been stymied in some areas. It appears as though it will be some time before the mess is cleared up and operators can carry out expansion plans.

Check it out

One final interesting note about the 900MHz frequency band.

Check out the exact wording of the FCC's recently adopted rule regarding coordination of modifications to private radio licenses for the purpose of *adding paging units.* See whether you think that the exemption includes 900MHz paging systems. It was *supposed* to, but . . .

*NABER is the National Association of Business and Educational Radio, an Arlington, VA-based trade association that coordinates frequencies for the Business Radio Service.

Readers' choice

Of all the new products and services in the March issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

RF modules boast range of 850MHz-960MHz

A synthesizer PROM control interface with an optional serial or parallel microprocessor control are in **RF Industries'** RF modules. Features include multiple channels, 12.5kHz or 25kHz channel spacing and a frequency range of 850MHz to 960MHz. The modules measure 2" x 2".

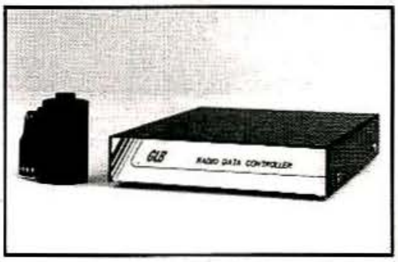
Circle (500) on Fast Fact Card

Hand-held unit transmits fax, alphanumeric paging messages

Pagentry is a hand-held fax transmitter and alphanumeric radio page message entry and transmission device. Measuring 3" x 5" x 3/4", the unit is battery-powered and contains an alphanumeric keyboard and LCD. Message text may be entered at any time and later transmitted to radio pagers or fax machines. The unit can transmit and receive E-mail, be used as a hand-held data terminal, or used as a TDD. The **RTS Electronics** unit also provides a name and telephone number directory, a touchtone dialer, alarm and reminder functions, and a calculator.

Circle (501) on Fast Fact Card

RDC suits GPS, public safety applications



The radio data controller (RDC) is capable of transmitting data over existing radio at 9,600bps or at 1,200bps on most trunked radios. Data communication takes place in either asynchronous or synchronous mode on either dedicated data or shared voice channels. The unit from **GLB Electronics** is user programmable and supports GPS, public safety, networking and data acquisition applications.

Circle (502) on Fast Fact Card

Transceiver leaves message if call isn't answered

SmallTalker IV two-way transceiver allows the user to selectively signal another user. If the user being called does not answer, the caller can leave an ID code on the called unit's LCD, indicating that a call was received and from whom. Available in VHF or UHF models, the unit from **Falcon Direct** covers 146MHz-174MHz and 450MHz-480MHz frequencies, respectively. Features include 99-channel capability, dual-priority scan, time-out timer, automatic number identification and selectable 4W/1W power output. DTMF encoding and decoding with CTCSS and two-tone sequential paging decoding options are available.

Circle (400) on Fast Fact Card

RF radiation suits protect in ambient RF fields

The Naptex RF radiation protective suit from **Maxwell Safety Products** is available in a safety-orange color to accommodate the telecommunications markets, where high-visibility is favored. Results from the Naval Aerospace Medical Research Lab show that complete compliance with the ANSI/IEE C95.1-1992 standard is achieved while wearing the suit in ambient RF fields as high as 125mW/cm² from 65MHz to 10GHz, and as high as 20mW/cm² below 65MHz.

Circle (401) on Fast Fact Card

Radio data controller supports as many as 24 communications ports

The RDC-101 radio data controller is a 486DX, 50MHz radio network control computer that can support as many as 24 communications ports for greater capacity and faster routing of RF messages. The RDC-101 from **ElectroCom Communications Systems** offers simultaneous signal processing and routing for all incoming messages. When receiving a message, the RDC-101 automatically updates the signal strength indicators and selects the best broadcast tower to optimize outgoing signal performance. It features a built-in digital diagnostic system to aid system monitoring.

Circle (402) on Fast Fact Card

Flexible communications cable is weather resistant

The LMR-600 flexible communications cable is ideal as an antenna feeder in outdoor land mobile and cellular communications applications. The cable from **Times Microwave Systems** uses a polyethylene jacket and a vapor-sealed aluminum tape outer conductor to make it weather resistant. Offering more than 90dB shielding efficiency and ±10 ppm per °C phase stability, the cable can be supplied in bulk or pre-terminated with Type N connectors.

Circle (403) on Fast Fact Card

Pager series offers carrier and user features

The **Uniden** XLT pager series offers sleek styled and user-friendly features and a variety of carrier features. Carrier features include out-of-range indicators; enable and disable message error display; solderless 1,200-baud and 2,400-baud capability; test mode; and a five-digit security code. As many as three wake-up screens can be programmed. User features include time stamp; day, date and time clock; multi-alarm features with six alerts; and memory location tags. The pager offers a 24-character message screen with 30 message capability, forward and backward scroll on memory, and delete individual or delete all message capability.

Circle (404) on Fast Fact Card

New products

Low power converter for cellular applications

The ICT2412-5AS converts 24Vdc to 12Vdc for cellular and other low power applications. The coating combines four types of silicones and two types of Loctite that makes the **ICT** converter vibration-proof and moisture-resistant. Other features include modular construction, compact size, high-efficiency MOSFET design and a terminal block for reliable electrical connections.

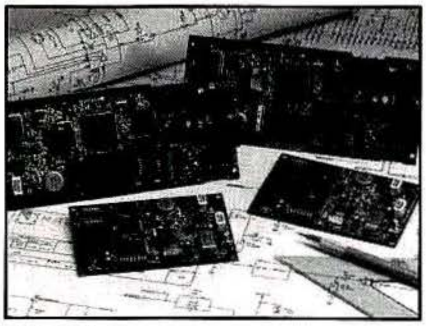
Circle (405) on Fast Fact Card

Multicoupler covers SMR trunking, cellular, GSM, PCN services

The antenna site receiver multicoupler from **Trontech** covers the SMR trunking, cellular, GSM and PCN services in the 800MHz-900MHz frequency range. The multicoupler can be configured with six to 48 output ports with a maximum noise of 2.5dB. Standard features include lightning protection, status alarms and low-loss filters.

Circle (407) on Fast Fact Card

Raw data GPS module available in two sizes and power supplies



The raw data firmware from **Magellan Systems** is set for higher accuracy applications, such as surveying, mapping and geographic information systems (GIS) data collection. The firmware joins the rest of the company's standard navigation firmware for its GPS Brain global positioning system receiver products. The module is available in two sizes and power supplies: 2.9" x 4.5" x 0.5" and 5V of power, and a slightly larger board that features a 9Vdc-16Vdc power supply.

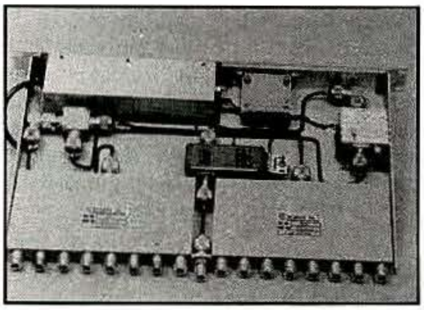
Circle (406) on Fast Fact Card

Batteries offer environmentally safe benefits

Non-hazardous batteries in zinc chloride, lithium and nickel-metal hydride configurations are available from **Falcon Direct.** The zinc chloride batteries are available in AAA, AA, C, D and 9V configurations. The long-life lithium batteries are available for use in Reach VIP series radio pagers and in a 9V transistor-type cell. Nickel-metal hydride rechargeable batteries are available in AA size configurations for many radio pagers and other electrical devices.

Circle (408) on Fast Fact Card

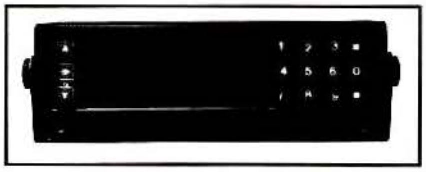
Receiver distribution panel uses one rack of space



Telewave's receiver distribution panels for VHF, UHF, cellular and 800MHz trunking applications measure 1.75" x 19" x 11", providing performance superior to units requiring two or three times that space. The 8-channel unit can be field-expanded to 16 channels or a distribution network of 64 channels by using four 16-channel expansion panels. The external dc input regulator allows the external input voltage to vary between +9.5Vdc and +15Vdc but keeps the output voltage constant.

Circle (409) on Fast Fact Card

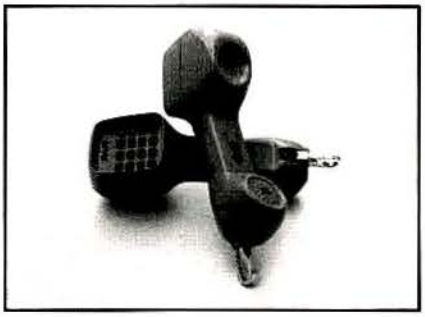
Mobile data system offers fleet management



Mobi-Script mobile data system from **Sigtone** allows a radio dispatcher to send text messages to mobiles and to receive short status messages from the mobiles. Text messages are displayed in the vehicle on a mobile data terminal screen. Received messages are automatically stored in memory for later retrieval. Menu selections allow retrieval of stored messages, entry of driver IDs, readout of keypad status designations and full selective calling.

Circle (410) on Fast Fact Card

Craft Hand test set adds speaker phone option



The MT-811 Craft Hand test set from **Metro Tel** offers audio boost and speaker phone option for hands-free operation. Features include nine 18-digit speed-dialing numbers with storable pauses and last number redial; tone or pulse talking; talk and monitor with high-quality audio; loop and ground start; mute; polarity; and over-voltage protection. A high-impact ABS housing and rubber mat dial pad are designed to withstand severe environmental conditions.

Circle (411) on Fast Fact Card

New products

Canadian elevation data are available on TAP system

Digital elevation data for the Canadian provinces and territories are available from **SoftWright.** The digital elevation models are integrated into the Terrian Analysis Package (TAP) system for extensive modeling of RF coverage for land mobile, cellular, paging, broadcasting and microwave radio systems. The TAP system is PC-based and can be used to design or evaluate existing or proposed transmitter sites and hardware configurations before construction.

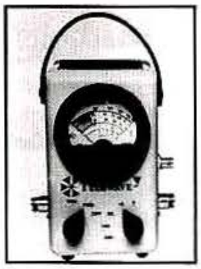
Circle (412) on Fast Fact Card

Audio delay board features complete DTMF tone mute

The UAD-100 universal audio delay board is inserted in the repeater receiver audio path before any audio switching circuitry to delay the audio before it arrives at the repeater transmitter. The unit from **Creative Control Products** features complete DTMF tone mute and squelch tail elimination. It comes fully assembled and tested with a detailed application manual and has a one year warranty.

Circle (413) on Fast Fact Card

Wattmeters cover frequencies from 2MHz to 1,000MHz



Models 44L1 and 44A RF wattmeters from **Telewave** are compact instruments used for direct measuring of forward and reflected RF power. Other features include 1W-500W measurement, five power ranges and Type N or UHF interchangeable connectors. The 44L1 covers the 2MHz-200MHz frequency range, and model 44A covers 25MHz to 1,000MHz.

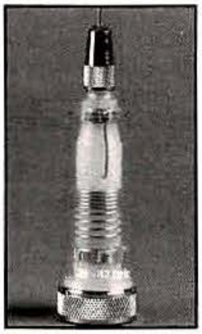
Circle (414) on Fast Fact Card

GPS receiver is the size of a credit card

NavCore MicroTracker from **Rockwell International** is a credit card-size 5-channel GPS receiver that measures 2" x 2.8" x 0.53" and weighs two ounces. The MicroTracker is designed to operate with an inexpensive passive antenna in most applications, allowing OEMs to reduce production costs of their end products.

Circle (415) on Fast Fact Card

Antenna features see-through coil for easier inspection



ClearTenna from **Falcon Direct** features a SeeVue coil which allows the user to visually inspect the antenna base for corrosion, moisture or broken coil windings. The antenna is available in VHF lowband, VHF highband and UHF.

Circle (416) on Fast Fact Card

Dummy load good for use past 500MHz

The RFU-551 is a 30W, 50Ω dummy load that works well for uses past 500MHz. The terminator from **RF Industries** has an extruded heat sink and a UHF male connector with an overall length of 2.5".

Circle (417) on Fast Fact Card

Accessories available for NEC Talktime cellular phones

Ora Electronics introduces the Quick Charger/Conditioner model QCC1NEC and the Starter-Kit model NEC100SK for the NEC Talktime series of portable cellular phones. The Quick Charger/Conditioner can charge NiCd rechargeable battery packs in one hour or less and can condition batteries to restore lost capacity. The Starter-Kit contains accessories such as the power cord, extended life battery and a leather case.

Circle (418) on Fast Fact Card

SCADA controller allows user customization

The Sprint 7010 programmable logic controller offers 16 analog input ports and 16 relay outputs for locations where remote control and data acquisition are needed. The fully programmable unit from **SMC Wireless** allows the user to customize the system to their specific application. Alarm and other messages can be sent directly to an alphanumeric pager. The unit operates from 12V of dc power with a standard 19-inch rack-mount design.

Circle (419) on Fast Fact Card

AVL system accepts any source of vehicle position information

MetroView from **Ball** is an automatic vehicle location system that uses the UNIX-based software package and Sun work stations equipped with high resolution displays. MetroView accepts any source of vehicle position information. The system communicates to the global positioning system (GPS) receivers via an interface to the customer's mobile radio system.

Circle (420) on Fast Fact Card

Enclosures house radio communications, solar equipment

The Samps modular solar power solution for powering radio communications combines modular solid-state solar power equipment from SunAmp Power with robust enclosures and an effective design method based on the PVCAD computer programs. Samps enclosures from **Photovoltaic Resources** are designed to house both radio communications and the solar equipment in one compact, secure housing. Custom colors and NEMA ratings are available.

Circle (421) on Fast Fact Card

New products

Adapters suit UHF T, right-angle, barrel applications

RF Industries offers the following UHF T, right-angle and barrel adapters. The RFU-533 T adapter includes two female and one male connector. The RFU-534 T adapter includes three female connectors. The RFU-532 right-angle adapter allows connection to any RF receiver or transmitter where a straight plug will not fit. The RFU-536 female-to-female barrel adapter allows cables to be spliced together with standard PL-259 plugs. All of the connectors are nickel-plated and meet military specifications.

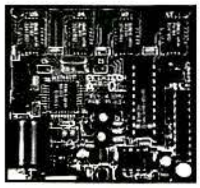
Circle (422) on Fast Fact Card

Enhancements available for synthesized netlink radio determination system

A series of enhancements for **GLB Electronics'** synthesized netlink radio determination system (SNRDS) is available. Previously available at 100MHz and 450MHz, the series now is available at 200MHz and 300MHz and recently received FCC approval at 806MHz-960MHz. Forward error correction increases throughput and area coverage in mobile applications. In applications where frequency stability is required manually rather than automatically programmed in the system, a manual switch capable of selecting as many as six channels may be added. When customers wish to replace leased lines and use their existing modems, a four-wire version of SNRDS is available.

Circle (423) on Fast Fact Card

Digital voice recorder records as much as 218 seconds



The AudioQ-218 digital voice recorder records as much as 218 seconds of speech. With four selectable sample rates standard (4.8kHz, 8.5kHz, 9.6kHz and 11kHz) and sample rates as high as 17.8kHz available, as many as eight variable-length messages may be stored. The messages are stored in battery backed-up RAM. The recorder from **GetTech** measures 2.6" x 2.6".

Circle (424) on Fast Fact Card

Responder tests cellular network

Model 366EC cellular responder from **Sage Instruments** provides automated two-way, end-to-end testing of a cellular network. Both automated and demand tests can be initiated. Testing scenarios include standard voice tests, deviation limit tests, RSSI in dB and bit error rate. Reports can be specified or customized to isolate and identify troubles in any part of the network.

Circle (425) on Fast Fact Card

Cooling shelter regulates temperatures without any power

Cool Shelter is a passive cooling enclosure that protects batteries and electronic equipment from extreme temperatures. The shelter from **Zomeworks** uses a Cool Cell cooling system that passively regulates temperatures without the use of any power. Tests reveal that the shelter maintains an internal temperature 20°F below the highest ambient temperature and extends the battery life between 30%-50%.

Circle (426) on Fast Fact Card

Circle (74) on Fast Fact Card

Circle (75) on Fast Fact Card

Quick-attach connectors install in less than three minutes

The C-41 quick-attach connectors use a collet compression design that makes attachment quick and easy while providing high retention against pull-off. This design can be field-installed in less than three minutes and does not require tab-flaring or soldering to the cable's outer conductor. The **Andrew** C-41 series connectors are available in the following types and configurations: type N plug straight and right angle; type N jack bulkhead; BNC plug; SMA jack bulkhead; and SMA plug straight and right angle.

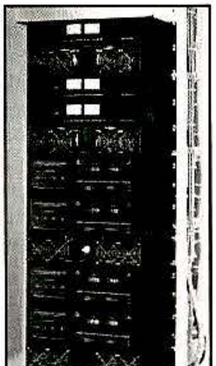
Circle (427) on Fast Fact Card

Crystal-controlled radios offer 5W of power, 4 channels

Monark offers crystal-controlled radios that feature 5W of power and four channels in VHF and UHF bands. The basic package includes high-quality crystals on one channel, 10.8Vdc, 600mAh NiCd battery, CTCSS encode and decode, belt clip, wall charger and molded antenna. Accessories include a Delta V desktop rapid charger, speaker/mic, plug-in CTCSS module, plug-in two-tone decoder and leather or nylon cases with swivel belt loop.

Circle (428) on Fast Fact Card

Customized power systems offer 13,500W per rack



Customized to individual communication site specifications, power rack systems from **Newmar** are fully integrated and outfitted for paging, cellular, microwave and telephone applications. System components include power factor corrected switch-mode power supplies in 750W and 1,500W models and isolated dc-to-dc converters for 12Vdc, 24Vdc and 48Vdc systems. Total power capacity is 13,500W per rack.

Circle (429) on Fast Fact Card

Dc-to-dc converters power radios in harsh environments

The 1620 series of dc-to-dc converters from **Wilmore Electronics** are suitable for powering voice and data radios in harsh environments, such as locomotives or other rail vehicles. The series include 100W and 200W models that provide input-to-output isolation, output voltage regulation and short-circuit protection. Operating temperature range is −40°C to +70°C.

Circle (430) on Fast Fact Card

Unit monitors for as long as four hours after power is lost

RemoteLinq from **Remote Monitoring of America** provides real-time monitoring and analysis of operations at remote locations by sending a digital message to a personal computer or broadcasting a pager message. The unit is encased in a 15.7" x 13.8" x 6.1" metal box with a microprocessor and stored logic, interfaces for sensors and communications interfaces for a cellular phone, landline phone or both. Sensors include current, power, light and intrusion detectors; and level, temperature and pressure gauges. The system can hold as much as a megabyte of memory, enough to allow individual applications for more than 30 days of detailed archival data. Using its backup battery, the unit can continue monitoring for as long as four hours in the event of a power line failure, sending an alert as soon as power is lost. It will reset itself after power is restored.

Circle (431) on Fast Fact Card

Circle (76) on Fast Fact Card

Circle (77) on Fast Fact Card

Brochure highlights non-ionizing radiation hazard meters

A brochure from **General Microwave** covers its Raham line of non-ionizing radiation hazard meters and models 60 and 65 RF radiation badge personal dosimeters. Descriptions include 12 models of Raham hand-held survey systems covering 200kHz-40GHz and two personal dosimeters covering 0.8GHz-40GHz. A technical description explains related theory of operation and terminology used in the radiation hazard monitoring field. The products are used to survey the work place for hazardous non-ionizing radiation, as well as to provide a sonic and visual indication of potentially harmful levels.

Circle (301) on Fast Fact Card

Catalog includes site management equipment

The 400-page 1993-94 catalog and price book from **Cartwright Communications** represents almost every product the company offers and contains more than 1,000 photos, charts and graphs. Ninety pages are devoted to site management equipment, including duplexers, cavities, combiners and multicouplers, and there are cross reference charts for duplexers, cavities and base station antennas.

Circle (302) on Fast Fact Card

Circle (78) on Fast Fact Card

Circle (79) on Fast Fact Card

Guide shows coaxial cable

A 16-page guide describes coaxial cable for land mobile, paging, microwave, broadcast, cellular and military applications. Illustrated with color photos, the bulletin describes the construction and benefits of **Andrew's** three types of coaxial cable: LDF foam, superflexible foam and air-dielectric. The guide lists complete electrical and mechanical characteristics of each cable in tabular form. Other sections cover installation accessories, as well as features and benefits of Premium Performance Type N and 7/16 DIN connectors.

Circle (303) on Fast Fact Card

Catalog displays electric parts, components

More than 20,000 high-demand parts and components are contained in a free catalog from **MCM Electronics,** and more than 1,400 of those items are new. Among the categories of products are semiconductors, power supplies, connectors, tools, batteries and test equipment. MCM has also expanded its line of computer and cellular products.

Circle (304) on Fast Fact Card

Catalog features attenuators

An 84-page catalog discusses attenuators, RF switches, power dividers, terminations and related components. New products in the catalog from **JFW Industries** include power dividers, rotary attenuators, programmable attenuators and an introduction to the company's matrix switch capability.

Circle (305) on Fast Fact Card

Brochure describes lightning protection products

A four-page color brochure from **Polyphaser** shows how its coax entry protection system works to divert as much strike energy to the ground as possible. The brochure contains detailed photographs showing phases of the copper bulkhead entrance panel kit installation with explanations of its features and advantages.

Circle (306) on Fast Fact Card

Catalog describes components

An updated and expanded component catalog from **Microflect** details more than 1,100 products designed to meet waveguide support and protection, tower accessory hardware and antenna support requirements. The catalog includes forms for customer-generated new product ideas, fax and mail ordering and a pricing diskette request card.

Circle (307) on Fast Fact Card

Data sheet discusses line of portable trunking mobilfones

A two-page data sheet covers the line of RTX 8500 portable trunking mobilfones which enable users to make and receive local, national and international calls. The data sheet from **RTX** describes and illustrates the operating features of the series of phones. It describes how a private dispatch channel can be included in any of the RTX 8500 multiple trunking groups. The data sheet also covers how the units work with any RTX-compatible controller.

Circle (308) on Fast Fact Card

Catalog details software products

A catalog of software products from **SoftWright** details its fourteen interactive modules of RF engineering software. Included are the Terrain Analysis Package (TAP), the Antenna Pattern Module and the microwave path budgeting software. The company also has digitized topography for all fifty U.S. states, Puerto Rico and the Virgin Islands, which can be read directly by its software.

Circle (309) on Fast Fact Card

Brochure illustrates fume extraction systems

The Tip-Evac fume extraction brochure shows a variety of fume extraction systems to remove harmful fumes from hand soldering operations. The brochure from **Pace** explains the benefits of fume source capture by removing particulates and gases before they reach the worker's breathing zone.

Circle (310) on Fast Fact Card

Selection guide details RF test instruments

An RF test instrumentation selection guide details **Wayne Kerr's** line of RF test instrumentation. Included are the 2.4GHz and 1GHz signal generators, the 1GHz spectrum analyzer and automatic modulation meters. The Easy 1 emissions assessment system is also featured.

Circle (311) on Fast Fact Card

Brochure describes spectrum analyzers

A 16-page brochure covers **Anritsu Wiltron's** MS2610 and MS2620 series of spectrum analyzers. It details all the capabilities of the five spectrum analyzers in the series. Included in the brochure are color photographs and charts. Specifications are highlighted, and applications of the spectrum analyzers are also described.

Circle (312) on Fast Fact Card

Application note discusses wideband transformers

A four-page application note titled "Wideband Signal Transformers" covers ideal transformers, practical transformers, effect of mismatch, low- and high-frequency response, group delay, saturation, balanced and unbalanced transformers, isolation transformers, bridging transformers and impedance matching transformers. A table of VSWR and return loss is included in the application note from **North Hills Signal Processing.**

Circle (313) on Fast Fact Card

Catalog contains FCC licensee data products

The "FCC Database Products" catalog has more than 600 FCC licensee data products such as state, regional and nationwide reports; radius searches; monthly subscription and update services; and a variety of custom data extracts. **Interactive Systems** receives updates from the FCC nightly and makes current licensee information available to the public the next day. Among the databases available are Part 90/95/22/68; PRB microwave; MDS; 220MHz-222MHz; tower; FAA airport file; PCP; RCC; and FCC administrative tracking information.

Circle (314) on Fast Fact Card

Report gives paging industry update

The State of the U.S. Paging Industry: 1993 is a report published by **EMCI** analyzing the paging market and economy. Included in the report are such topics as paging subscriber growth projections until 1997; paging equipment sales and manufacturers' market share; analysis of pagers by type; average revenues generated by type of pager and size of company; and analysis of proposals for advanced paging and messaging technology. Another report, *Digital Cellular: Economics and Comparative Technologies*, provides an analysis of the market, economics and technical aspects of digital implementation.

Circle (315) on Fast Fact Card

(continued from page 54)

On-center narrowband channels will be used. This method allows existing channels to be upgraded without having to create new narrowband channels.

F-TDMA on refarmed spectrum

The refarmed spectrum allows two TDMA carriers 12.5kHz apart on a 25kHz channel. (See Figure 3 on page 52.) This method allows four users on the equivalent of one current channel.

F-TDMA technology provides the best solution to satisfy the need for increased spectrum efficiency in land mobile radio while offering the flexibility of supporting high data rates. Moving to narrowband channels alone, as proposed by Project 25, is inadequate to meet the demand for increased spectrum. (Project 25, a joint effort of the Associated Public-Safety Communications Officers, the National Association of State Telecommunications Directors and federal agencies, seeks to set digital radio standards for public safety radio communications.)

Although the use of analog technology may continue for some time, in due course digital will supplant analog. It is imperative that sound migration plans be available for the transition from analog to digital systems and for maintaining backward compatibility between existing and upgraded systems.

F-TDMA offers backward and forward compatibility. F-TDMA technology has a migration path to achieve a capacity of four users in 25kHz channels under uniform emissions standards. Furthermore, the F-TDMA architecture is fashioned to accept increases in spectrum efficiency.

F-TDMA will benefit significantly from technological advances in other fields. Microprocessors, software and batteries will be leveraged for private land mobile radio systems. Using such components provides economies of scale that will help to lower the price of TDMA.

F-TDMA data performance

F-TDMA inherently provides 67% higher throughput (16kb/s vs. 9.6kb/s in 12.5kHz channels) than FDMA.

Data applications that require transmissions of fingerprints and retinal scans require wider bandwidths. F-TDMA provides the flexibility to combine bandwidths of multiple time slots and pass data, which requires a wider bandwidth to transmit.

F-TDMA offers a path that allows refarming of existing spectrum below 470MHz to 12.5kHz spacing by on-center channel migration while delivering a 100% increase in efficiency.

Current 800MHz radio users can maintain their existing 25kHz channels and gain a progressive efficiency increase to four users per channel using F-TDMA.

F-TDMA will be developed and implemented with product availability within the next two years.

WirelessWorld™ Conference & Exhibition

November 2-4, 1993, Buena Vista Palace, Lake Buena Vista, FL

Schedule At-A-Glance

		TRACK 1 Networks & Technology	**TRACK 2** Wireless Issues	**TRACK 3** Sales & Marketing
Tues. Nov. 2	10:00-11:45 AM	Opening General Session		
	12:00-1:30 PM	Keynote Luncheon		
	1:45-3:15 PM	Reaching for Capacity	PCS: Vision vs. Reality	Resellers, Dealers & Agents
	3:15-6:30 PM	Exhibits/Vendor Demonstrations		
	6:30-7:30 PM	Cocktail Reception		
Wed. Nov. 3	7:30-8:30 AM	Continental Breakfast		
	8:30-10:00 AM	Network Management	PCS & Wireless Regulations	Making Even *More* Money
	10:00-10:20 AM	Coffee Break		
	10:20-11:50 AM	The Intelligent Network	Fraud & Billing Issues	Dual Modes, Digital & Analog
	12:00-1:30 PM	Lunch with Exhibitors(Exhibits Open)		
	1:45-3:15 PM	IS-41 & Roaming	Filling in the Gaps	Crime & Punishment
	3:15-6:30 PM	Exhibits/Vendor Demonstrations		
	5:30-6:30 PM	Cocktail Reception		
Thurs. Nov. 4	7:30-8:30 AM	Continental Breakfast		
	8:30-10:00 AM	The Digital Microwave Link	Working With Small Markets	The World According to Data
	10:00-10:20 AM	Coffee Break		
	10:30 AM-12:00 PM	Closing General Session: Cellular, EMF & You		

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A limited number of exhibit spaces are available. Call Ms. Billi Famiglietti, E.J. Krause & Assoc., at 301-986-7800 for more information!

Feedback

Technicians' pay

Technicians' estimated median salary is $34,166 according to respondents to the March "What Do You Think?" questionnaire. Median refers to half of the group being above this figure and half of the group being below this figure. The estimated median years in the industry is 12.8 years. Salary statistics include:

SALARY RANGE	%
Less than $15,000	6.0%
$15,000 to $19,999	9.5%
$20,000 to $29,999	23.8%
$30,000 to $39,999	28.6%
$40,000 to $49,999	22.6%
$50,000 or more	7.1%
No answer	2.4%

The majority of the technicians, 52.4%, responded that their respective salaries are favorable for their type of operation and position. Comments include:

- "It is favorable. Salary isn't everything. Benefits mean more the way things are."
- "It's comparable to other companies' salary range for communication technicians."
- "I also get extensive benefits and profit sharing."
- "Low cost-of-living area. Salary determined by the department of labor."
- "Considering the economy at the present time. If times get better, customers buy more and salaries increase to match usually."
- "Sufficient for my needs, respectable for my 'position' in the company."

A close 47.6% maintained their incomes are not favorable. Comments include:

- "For the responsibility, stress and liability, I do not receive adequate compensation."
- "I've worked hard to improve myself and been rewarded with 'we're sorry, you deserve a promotion, but we don't have the funds at this time.'"
- "Only game in town. Work for nothing or don't work at all."
- "Cost of living seemingly not considered."

Readers noted the following information that they would find helpful when negotiating a pay increase:

- "Importance of technical knowledge and skills."
- "Job experience, job knowledge, technical knowledge and relationship with customers."
- "Knowledge gained on new products, knowledge retained on older products."
- "New technology trends and directions to show relationship with employee skills existing or being developed through training."
- "Personal productivity and business trends."
- "Technical certification, job variety and experience, ability to do the tasks requested of me."

Trends that technicians see in land mobile salaries include:

- "Stabilizing salaries with peaks for specialities."
- "Staying the same or in some cases are dropping off. I don't think we are getting paid enough, considering time and dollars to keep continuously up-to-date on state-of-the-art knowledge."
- "Salaries will increase for better trained and more skilled tech. Technology will demand higher skills for better pay."
- "As more troubleshooting and planning become computer oriented, I believe salaries will increase competitively."

People

Lohan

Corrigan

Mitri

Monto

Changes at M.I.N.K. Marketing, Olathe, KS:

Don Pizzella closes his communications business to join M.I.N.K. Marketing as a sales representative for commercial communications equipment.

David Wall leaves Mountain Representatives, Denver, as a sales representative to join M.I.N.K. Marketing as a sales representative for the mountain states region.

Changes at Sigtone, Winter Park, FL:

Pat Lohan exits Communications Design, Longford, Ireland, as technical director to join Sigtone as senior sales and application engineer.

Larry Bess, corporate vice president and general manager, has been elected to Sigtone's board of directors.

Jorge Medina, Central and South American sales engineer, advances to international sales manager.

Walt Corrigan departs Communications Electronics Specialties, Winter Park, FL, as manager of sales to join RTX, Melbourne, FL, as director of product sales.

Michael Powell exits Systematics Telecommunications Services, Little Rock, AR, as regional sales manager to become national sales manager for Subscriber Computing, Laguna Hills, CA.

Appointments at newly formed Strategic Telecommunications, Dallas:

Robert C. Shapiro, P.E., concludes contract consulting with Ram Communications Consultants, Dallas, to become Strategic's president.

James Schell exits Northern Telecom, San Ramon, CA, as switching systems engineer to become the company's network engineering vice president.

Kevin Henry leaves Nippon Motorola, Osaka, Japan, as cellular field engineer to join Strategic as marketing vice president.

Tim Tilton, a contract engineer, joins the company as vice president of MidEast Operations.

Elias Mitri leaves Maxtor, San Jose, CA, as operations manager to join Western Multiplex, Belmont, CA, as director of operations.

Jerry Mulder leaves Andrew at the Denton, TX, facility as the company's marketing specialist to become director of technical projects for FWT, Fort Worth, TX.

John E. Monto leaves Metromedia Paging Services, Los Angeles, as senior corporate accounts representative to become major accounts manager for the mobile antenna line at Allgon Mobile, Grand Prairie, TX.

Letters to the editor

Last technician:

I just had to take you up on your request for comments on Rod Wheeler's crystal-ball version of two-way radio. (See the May 1993 "Letters" column.)

Ron is right on target when he foresees less need for skilled technicians in the radio and wireless world of tomorrow. This trend was looming on the horizon long before computers and microprocessors came into fashion.

Each new radio or system just seemed to be designed with less human intervention required in alignment, repair and implementation. This is the trend in all manufacturing, trade and commerce these days.

So, what does it mean for us in the industry and those who may consider a career in radio and wireless communications?

Well, one thing is certain, and that is that people want to talk or communicate now more than ever. The way they do it will change, and the medium used will be controlled by large corporations rather than individual base station and mobile users, as has been the case in the past.

Shops that just rely on traditional two-way servicing and installation will go the way of the dinosaur. Technicians and shop owners will have to diversify beyond two-way to prosper until the next generation of technology creates a need for repairs and skilled technicians again.

The new technology, if and when it comes, will require new skills and talent when it first is deployed and perfected. This was the case with broadcast radio, telephone and now two-way radio and cellular networks.

The technician of the '90s and beyond will have a computer and lots of system knowledge in his "toolbox," rather than a Simpson 260 and Bird wattmeter. He or she will be handling calls for fax machines, personal computers, local area networks, modems, T-1 and radio/wireless. The future might be quite bright for those with the courage to look ahead, imagine a little and meet change head on.

It sure helps, too, if your boss or company has the guts to plow ahead with change when everybody else sticks their head into the sand.

Change really is our friend and gets us to grow and develop. It is uncomfortable at times, but just as new shoes do, we have to be broken in a little and molded to the new surroundings. Good luck!

Rich Merkel
Senior Telecom Specialist
Federal Express
Union, NJ

Fast Fact Card comments:

The two toughest problems facing me on the job are:

- keeping up with technology.
- tracking down desense on a tower with 40 two-ways and three TV stations.

W.B. Huddleston
Houston Radio Repeater
Houston

The two toughest problems facing me on the job are:

- identifying and keeping track of our users.
- getting the time to test new applications.

Jan Hunt
Telecommunications Specialist
3M
St. Paul, MN

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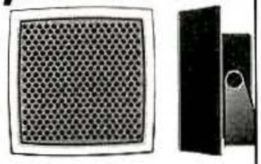

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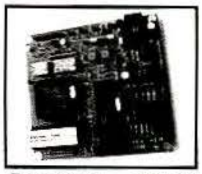

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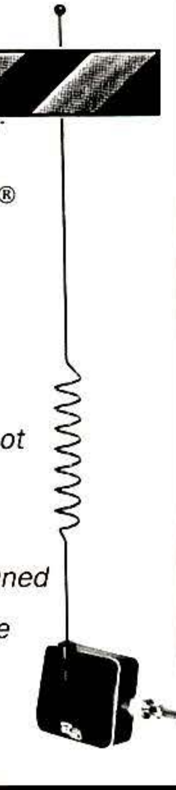

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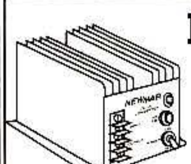

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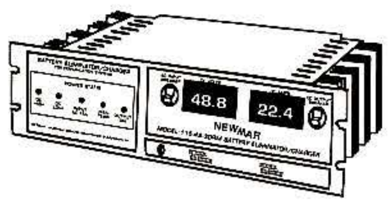

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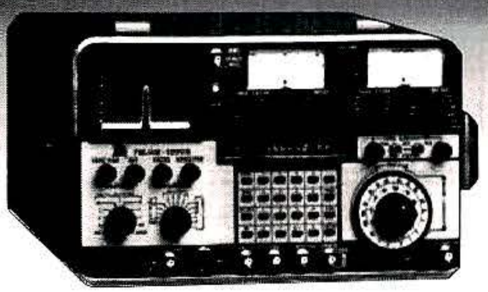

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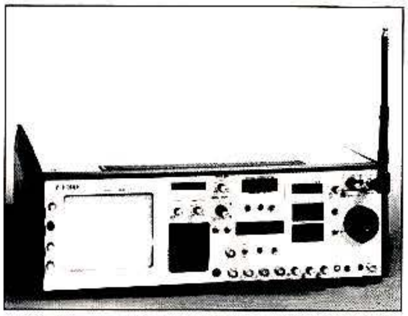

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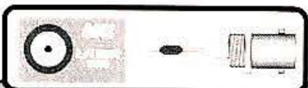

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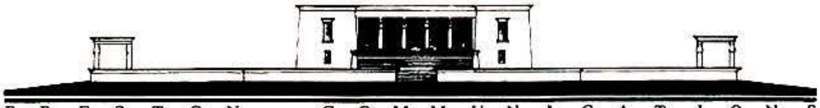

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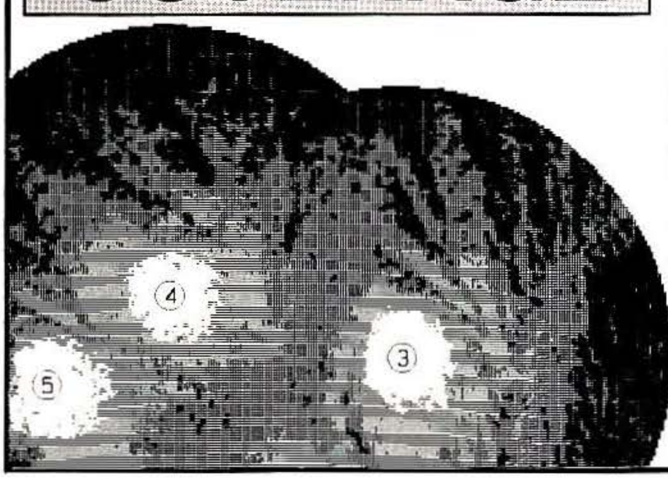

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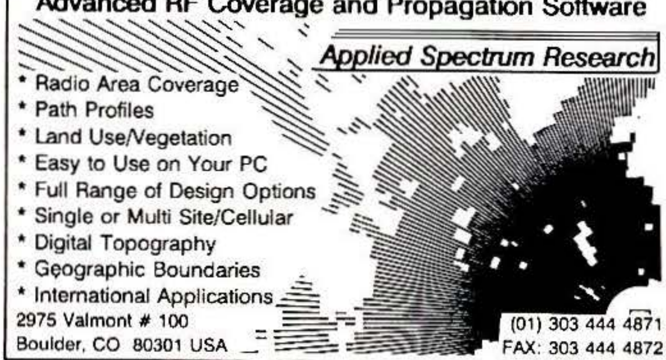

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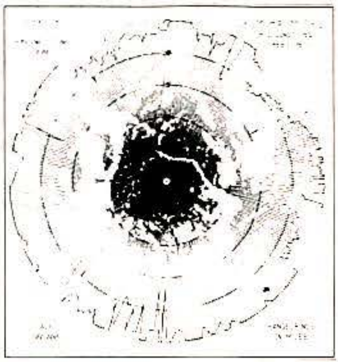

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Norton Engineering	103	131	703-938-5745
Omnicron Electronics	73	68	203-928-0377
PageTek, Inc.	26	22	919-876-8294
Paging Products International	65	58	713-991-4930
Paging Wholesalers	75	72	818-240-5640
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